Gift from
George E. Martin
May, 1983

AN APPLE GRAFT ONE YEAR OLD

As evidence of the success of Mr. Burbank's methods in producing quick results, this apple graft, in full bearing after only one year's growth, speaks eloquently.

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HOW PLANTS ARE TRAINED
TO WORK FOR MAN
BY LUTHER BURBANK Sc.D

FRUIT IMPROVEMENT

VOLUME III

EIGHT VOLUMES · ILLUSTRATED
PREFATORY NOTE BY DAVID STARR JORDAN

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IT IS traditional that you cannot teach an old dog new tricks. The maxim applies with full force to old plants. You may bend the twig and make a permanent twist in the future tree; but the hardened stock of the matured branch will return persistently if bent, and will break rather than change its form.

Now there is something like the same difference in flexibility between young and old races of plants. Here is a variety of plant that has been developed in the orchard or garden, under man's influence, in the course of the past few generations. It tends to vary, and its progeny may be made to adopt themselves to different conditions; by selection, they may be developed into divers and sundry new races.

But yonder pine or palm tree has no such inclination to vary. Its ancestors have remained substantially unchanged, true to their racial type,

generation after generation, for untold centuries. They represent an old, fixed, conservative stock. No one knows how to make them change, except within the narrowest of limits.

There is a very essential time element, then, that is instrumental in determining the fixity or variability of a race of plants. A plant that has been bred true to a given type for long periods of time, as is the case with the generality of wild plants, will breed substantially true from seed, and as a rule will maintain its racial type even if transplanted to new surroundings.

But, on the other hand, most of our cultivated plants are of mixed ancestry. Man has, within recent generations, changed them and adapted them to his needs. He has constantly been crossing them, or placing them under conditions that resulted in their combination through the visits of bees; and he has selected and cultivated the individual specimens that tended to vary, and thus fostered the habit of variability rather than that of fixity of character.

In the case of most orchard fruits, as we have had occasion to observe more than once, so many strains are blended that propagation from seeds is quite out of the question; unless, indeed, it be desired to secure seedlings of varying qualities in

the interests of experimentation, or in the attempt to develop still better varieties.

One might plant a thousand acres with seeds of the Baldwin apple, without perhaps producing a single plant that would precisely duplicate the qualities of the fruit from which the seeds were taken. And the same thing is true in greater or less measure of the majority not merely of orchard fruits but of most other cultivated plants.

The notable exceptions are annual plants that are habitually grown from seed, such as melons and peas in the garden, and the great tribe of cereals represented by wheat, oats, rye, and barley. The reason why all of these breed fairly true from seed is that they are necessarily propagated in this way alone, and it has been essential that fixed races should be developed.

Mankind depends largely upon the cereals for food, and his existence would be altogether precarious could he not have reasonable assurance that when he sows grain of a certain kind and quality he will secure a crop of grain of similar quality.

The fixity of character of the cereals and various other plants, including peas and beans, is enhanced and assured by the fact that the flowers of these plants are habitually self-fertilized. If you examine a head of wheat at the right stage,

you will find that you must pull open the little bracts in which the flowers are incased, in order to make the stamens and pistils visible. Under ordinary circumstances, insects cannot find access to them. The wind has no influence over them. Their normal habit is to fertilize the pistil of each individual flower with pollen from the stamens that grow within the same closed receptacle.

This is inbreeding of the closest and most intimate character, and there is obviously no general opportunity to introduce the element of variability which, as we have seen illustrated over and over, cross-fertilization brings.

So the essential qualities that make wheat valuable have been aggregated in a few fixed combinations, and the resulting varieties of wheat, differing not very widely from one another, are rarely crossed, unless by artificial means to meet the special needs of the plant developer.

They remain fixed because they are of pure lineage.

Mixed Ancestry and Inbreeding

The case of the wheat is typical. Its development furnishes an illustration of the method through which many specialized races of animals and plants under domestication have been developed. Indeed, it might almost be said that the

one rule that has actuated the developer of special races has been to apply the principle of inbreeding. When an individual appeared in a herd or flock that showed certain peculiarities that the owner thought desirable, the natural and obvious way of perpetuating these was to breed from that individual; and then persistently, for a time, to inbreed the progeny in order to accentuate the desired trait.

The result has often been all that could be expected. Take, for instance, the case of the trotting horse.

It is, I believe, a matter of record that practically the entire stock of trotters, as developed in America in the past hundred years, descended from a single ancestor, the celebrated "Messenger." This individual horse chanced through some accidental mixture of ancestral strains to combine in its organization the particular qualities of nerve and muscle that adapted it for rapid progress by trotting instead of by the more natural method of running.

And as regards this quality or combination of qualities, the horse proved amazingly prepotent.

Its descendants soon constituted a race of trotters. Pedigrees were kept; the best individuals of the new race were selected as breeders; closely related animals were mated; and the character-

SEEDLESS GRAPES

This shows one of our choicest varieties of new seedless grape. They have been developed by selection, and are of delicious quality, with an added attractiveness due to the entire absence of seeds. Of course a fruit thus developed must be propagated by cuttings, and is not susceptible of further improvement except by crossing with a seed-bearing variety.

istics that make for speed at the trotting gait were in a few generations so fixed that a new race of horse was produced.

The principle thus illustrated applies with equal force to the breeding of plants. Indeed, it is possible here to hold even more rigidly to the idea of inbreeding, inasmuch as the individual flowers may be self-fertilized. We have just seen this illustrated in the case of wheat and allied cereals.

There is no question whatever that any given characteristic of a plant, once it appears, can be accentuated and fixed, first in individuals, and finally indelibly in the heredity of the descendants of the plant by systematic inbreeding.

But, unfortunately, there are complications in the case of most experiments that the originator of new plants is called upon to undertake that rob the method of its simplicity. The complications arise from the fact that the would-be originator of new races of fruit or flowers is usually seeking to develop not merely a single quality, but a *number* of qualities. And this alters the case fundamentally.

In the case of the trotting horse, the one all-essential quality desired is speed.

The capacity to trot a full mile at high speed does, indeed, imply the possession of stamina and

courage, as well as capacity for rapid action of the legs. These are qualities that are necessarily linked with the capacity for the right kind of muscular action.

But beyond this there are very few qualities upon which the breeder must insist. It does not greatly matter whether the speedy animal is small or large; its color is mostly a matter of entire indifference; and it is taken as a matter of course that the record-breaking animal will be nervous in temperament, tender as a hothouse plant, and requiring such care and attention as would be only wasted upon a more plebeian animal.

In a word, the breeder of trotting horses fixes attention principally on the single quality of speed.

But it is rare indeed that the would-be developer of a new plant can thus fix attention upon any single quality to the disregard of other qualities. On the contrary, as a rule, the plant experimenter, while he may have in mind one most important quality, must consider at the same time six or eight or ten or a dozen other qualities that are only a degree less essential. We have seen this illustrated again and again, and we shall have occasion to recall some of the specific characters involved in the course of the present discussion.

In reality, the task of the experimenter who would develop a new and really valuable variety of plum or cherry or apple or spineless cactus, is to be compared not with the task of breeding trotting horses as they are, but rather to the task that would confront the breeder were he to attempt to develop a race of trotting horses which should retain the capacity to trot a mile in less than two minutes, yet at the same time should be big and powerful enough to serve on occasion as draught horses; should be always of some predetermined color, say bright bay; and should be as hardy and require as little attention as the toughest broncho.

It requires no great amount of imagination to see that the task of breeding race horses would be quite different from what it is, even with the few specifications such as these.

Yet I repeat that the qualities that the plant experimenter usually seeks to combine in his new variety of flower or fruit are at least as varied and as difficult to fix in combination as the qualities just suggested for the supposititious new breed of race horses.

The Shasta on the Witness Stand

Let us by way of illustration recall the case of the Shasta daisy which, the reader will

remember, was developed by the union of three different species of flowers, coming respectively from Europe, America, and Japan.

It will be further recalled, that the ideal daisy that I had in mind for years before it became an actuality, showed in superlative degree a considerable variety of qualities that were not found in combination in any one of its ancestors. Indeed, the Shasta daisy, as ultimately developed, reveals a number of very conspicuous and important qualities that are not shown at all in any one of its known progenitors.

To make the illustration specific, we may cite, among the qualities that are assembled in the finished product, the following: (1) extreme size, (2) dazzling whiteness, (3) broad rays, (4) double rays, (5) gracefully drooping rays, (6) keeping quality of flower, (7) smooth stem, (8) early and persistent blooming, (9) hardiness, (10) constant bearing.

The perfected Shasta daisy manifests these qualities in supreme degree. As regards each and every one of them, it surpasses any of the parental forms from which it sprang; indeed, as to some of them, such as double and drooping and fluted rays, it shows an entire departure from all of its observed ancestors.

But to assemble these qualities in a single flower required about fifteen years of persistent effort, and the handling of probably not less than half a million individual seedlings.

Generation after generation the plants were cross-pollenized and selected over and over, always with an eye not merely to a single quality, but to the ensemble of all these ten qualities.

And always we were confronted with the difficulty that in reaching out to bring in some new quality, we were disturbing the balance of qualities already attained, and endangering the entire structure.

When, for example, the final cross was made with the Japanese daisy, to secure if possible the element of whiteness shown preeminently by that flower, and add it to our mosaic, we, of necessity, brought in also from the Japanese parent, along with the quality of whiteness, such undesired qualities as crude, ungraceful stems and very small flowers.

It was necessary to select and interbreed, and select again, for successive generations from among a multitude of the progeny of this cross, before a plant was finally secured that presented the desirable combination of qualities, retaining the whiteness of the Japanese parent, but rejecting its undesired characteristics of leaf and stem,

and departing utterly from that particular parent in point of size.

But, although an individual was at last found that did combine all the desired qualities, the very fact that this individual had been built up by putting together *this* quality brought from one parent and *that* quality from another, with the rejection of antagonistic qualities in each case, makes it inevitable that the perfected Shasta should contain latent in its system a whole coterie of tendencies which are striving for recognition, and which will make themselves felt in subsequent generations.

Hence it is that when seeds are gathered from the perfected Shasta they will not give us a crop of flowers like their parent. On the contrary, they will show the utmost diversity of form and size, making tangible thus the persistent force of the hereditary tendencies that had been transmitted from diverse ancestors, but which were submerged or made latent, simply because they were momentarily subordinated to opposing qualities, in the case of the perfect Shasta.

The Shasta daisy, then, while individually almost a perfect embodiment of the ideal at which I aimed, is when reproduced from seed anything but a fixed type. Had it not been possible to propagate the plant by division and then by an

unending series of successive divisions to produce an indefinite number of individuals, each precisely like the original because they were in a sense a part of it, my entire series of experiments in developing the new daisy would have been mostly unavailing except for still further selection. But, as the case stands, it was possible rapidly to develop an entire race of Shasta daisies by root division, and thanks to this method the descendants, or, to speak somewhat more accurately, the *sisters* of the original Shasta daisy have become an enormously populous race, scattered to the remotest parts of the earth.

Several other types of Shasta have been developed by new breeding experiments from the original stock, but to this day the best races of Shasta daisies must be propagated from the root, and not grown from seed, unless one desires a conglomerate progeny, departing in many ways from the form and quality of the immediate ancestor.

Fixing a Type

In all this, it must be recalled, the Shasta daisy does not differ from a large number of long-established cultivated plants that are everywhere recognized as being "fixed" races.

One does not produce apples or pears or cherries or plums or blackberries or potatoes or sugar

cane or horse-radish, to say nothing of roses, ornamental shrubs, and a great number of flowering plants, from seed.

They are propagated by grafting or budding, or by rooting the stem or dividing the roots or planting the tuber. And the reason in each case is the same. The perfected variety originated from a single individual that combined a large number of desirable qualities, and the entire company of individual representatives of that variety, though they be numbered in millions, are not really descendants, but offshoots, a part of the original individual.

Each cion or bud from a given tree will produce fruit precisely like that from the tree from which it is taken, because it is itself a part of the tree. And however widely new cions and buds from the first tree may be disseminated, they carry the same traits, because, rightly considered, they are a part of the same individual organism. The Seckel pear tree that grows in your dooryard is, from the standpoint of heredity, a tree of the same generation with untold thousands of other Seckel pear trees that have grown here and there across the hemispheres for more than a hundred years—or since the first one appeared in the orchard of the Pennsylvanian whose name they bear.

Were it not for the contradiction of terms, one might say that all Seckel pear trees constitute a single tree.

All these Seckel pear trees are essentially alike; they bear fruit that may vary in size and lusciousness with varying conditions, but that is everywhere essentially identical in flavor and in the characteristic qualities of texture and color. But if you plant the seeds of one of these pears you do not secure Seckel pears, unless by the merest chance, among the progeny. You secure instead, representatives of a galaxy of ancestors, no one of them individually just like the Seckel, although *collectively* they represent all the qualities of that fruit, plus almost numberless undesirable qualities.

Pairs of Qualities

The fact that our most familiar and best prized fruits and flowers show this lack of fixity suggests that the inherent difficulties in the way of fixing the type of these plants so that they will breed true from seed are very great. Otherwise some one would long ago have remedied the defect, for the advantages of being able to grow these useful plants from seed are obvious.

Nevertheless, it should not be assumed that the task of fixing the type of a newly developed race of fruit or flowers is of necessity a hopeless one.

The truth is that it would be possible to fix the type of almost any variety of plant, provided time enough and patience enough were devoted to the task, and the experiment were conducted on a wide enough scale. Indeed, nothing more would be necessary than to continue for an additional number of generations the same line of experimentation through which the new varieties were produced; attending carefully at all stages to the analysis of the different qualities that prove to be mutually antagonistic.

To this end, the new terminology which endeavors to analyze the qualities of a given plant into complementary pairs of unit characters may prove very helpful, particularly to the inexperienced investigator.

Such an analysis has always been made, tacitly at any rate, by the successful plant experimenter. No one can think of the development of an *early*-fruiting cherry or prune without having in mind the quality of *late*-fruiting. To speak of a prune with *high* sugar content implies one with *low* sugar content.

In a word, the desired quality of fruit or flower at which one aims is always balanced against the opposing quality—sweet fruit against sour, hardiness against tenderness, resistance to disease against susceptibility to disease, profuse bearing

against scant bearing, thorny brier against smooth brier, black fruit against white fruit, and so on down the list.

It is only by constantly bearing these divergent pairs of qualities in mind that any experimenter can hope to advance toward the production of an ideal fruit or flower or vine. And it has always been so.

Old Wine in New Bottles

But there can be no question that the new terminology, as used by present-day biologists, serves to give precision to the ideas of the plant experimenter, and enables him to analyze the results of his experiments in more precise terms than have hitherto been available.

It will be convenient, therefore, and probably helpful to the reader, in making precise reference to some of the experiments in plant breeding already detailed, with special reference to the possibility of fixing the type of new races, if we discuss the matter in the new terminology.

It will at once appear that when a plant developer attempts to fix a certain type, he is fundamentally changing his point of view. Hitherto he has been concerned to make plants vary in order that he might seize on new forms and use them as material for developing the type at which he aims. And his success in

A BASKET OF PLUMS

These plums are typical of bushels that might be picked during the bearing season on the grounds at Sebastopol, consisting of specimens no two of which are alike, and no one of which is identical with any variety hitherto known. During the past thirty years I have introduced more than sixty new varieties of plums selected from five hundred thousand seedlings. There are many varieties still unnamed that merit introduction, and new varieties of value appear each year. (Reduced one-half.)

developing a new race is largely dependent upon the extent to which he has been able to induce the plants with which he experiments to vary.

So now, when he attempts to restore fixity to something that he has purposely made unstable, he is at once confronted with the danger of undoing much that he has accomplished. The measure of success that he can hope to attain will depend very largely upon the particular kind of unit characters that he has combined in the product that he now wishes to make stable.

We have seen that, as between the opposing members of any pair of unit characters, it is usually discovered that one has prepotency or dominancy over the other. When blackberries of normal color, for example, are crossed with the white blackberry, the progeny are all black, because this color is the dominant member, and white the recessive or negative member of the pair of unit characters. But we saw also that the recessive trait will reappear in the succeeding generation, and that when it does reappear, it will, within certain limits, thereafter breed true.

So, when in the second generation we again produce a white blackberry, we have a type which is fixed as regards the particular character of whiteness. In other words, our white blackberry, even though both its parents, and one

grandparent, were black, may be considered a berry of pure white strain. From the moment of its appearance it is a fixed type as to color.

But, unfortunately, it is not sufficient that the white blackberry should breed true as regards the quality of whiteness alone. There are other qualities of size and flavor and many others that are equally essential. And these, it would appear, include sundry other pairs of unit characters—sweetness versus sourness, large size versus small size, profuse bearing versus scant bearing, and the like—that are represented in our berry by mixed factors.

In the Mendelian view, it will be recalled, there are always two factors representing any pair of unit characters.

In the case of our white blackberry, in the Mendelian view, both factors for the unit character blackness-versus-whiteness are of the white order; or in the technical phrase, the berry is "homozygous" for that pair of factors.

But as regards, let us say, the factor for the unit character bigness-versus-smallness the case is different; for this character may chance to be represented by one factor of each type. In other words, resorting again to the technical language, the berry may be "heterozygous" as regards that character.

In this particular generation the quality of bigness prevails because bigness is dominant to smallness. But the factor for smallness must have a hearing in the next generation.

Until we can produce a white blackberry that is "homozygous" for size factors as well as for color factors, we shall not obtain a fruit that will breed true to size as well as color.

A similar analysis might be applied to the various other pairs of unit characters that are represented in any given fruit or flower. And the essential principle, stated in Mendelian terms, to be aimed at by the experimenter who would fix a newly developed type of plant so that it will breed true from seed, must be to render the plant "homozygous" for the factors of each pair of unit characters involved. If that can be done, the plant will breed true; if that cannot be done, the plant will not breed true.

In the olden phrasing, this would be spoken of as "line" breeding—a method long familiar to every breeder of plants or animals.

Fixing a Type in the Second Generation

In actual practice, where only two or three unit characters are involved, it may be possible to produce a new type that breeds true, or is

fixed, in the second generation. In such a case the time element may be ignored.

Take, by way of illustration, Professor Castle's guinea pigs, to which reference has more than once been made. Suppose we have as parent stock a black guinea pig with a smooth coat, and a white guinea pig with a rough coat. Now we have already seen that blackness is dominant to whiteness as regards the coat of the guinea pig, and we must further understand that roughness of coat is known to be dominant to smoothness.

We must expect, then (according to Professor Castle), that when a cross is made, the guinea pigs of the first filial generation will, unlike either parent, be black in color and rough as to coat.

But, in the succeeding generation, the black, rough-coated guinea pigs being interbred, there will be a certain number of offspring that combine the dominant characters of blackness and roughness of coat, and will breed true to these; a certain number will be black and rough-coated, but will bear the latent characters of smoothness and whiteness of coat which will reappear in their progeny; and, finally, there will appear individuals combining the two recessive traits of whiteness and smoothness of coat.

These white, smooth-coated individuals are obviously different from their parents, and different also from either of their grandparents. They constitute a new race, sprung into being in a single generation, and a race that will necessarily breed true as to the character of smooth coat and white coat, because they are "homozygous" as to the factors for both these recessive characters.

Their progeny cannot be black because their germ plasm contains no hereditary factor for blackness; nor can their progeny be rough-coated, because their germ plasm contains no hereditary factors for rough-coatedness.

Yet, side by side with this new fixed race of smooth-coated white guinea pigs, there are, as we have seen, twins of the same fraternity that, instead of being white and smooth in color, are black and rough. And these also constitute a new race that will breed true because they contain, as regards the unit character for color and for condition of hair, only the dominant factors of blackness and roughness. They also are "homozygotes," but they are of the opposite type—dominants instead of recessives.

Meantime, we must not overlook the other members of the fraternity, twin brethren of these new races, which are individually black and

rough, but which are "heterozygous" as regards the unit characters under consideration, and hence will show progeny of variously mixed characteristics as to roughness or smoothness of coat, and as to black or white color.

This illustration, perhaps, gives as tangible an impression as can well be gained of the complexities that confront the experimenter when he attempts to fix a new type of animal or plant.

I may state here that dominant characters in any race are usually those more fixed in the past by innumerable repetitions; generally ancient and more fundamental characters.

Even where only two unit characters are involved, the progeny of the second generation, as we have just seen, may break up into numerous races, some fixed and others variable. And, as we have previously pointed out, the complications thus introduced increase at a startling ratio when more characters are under consideration.

Moreover, the matter is rendered increasingly difficult for the plant experimenter by the fact that he must often wait, particularly in the case of orchard fruits, for a term of years before he can know the result of any single breeding experiment. To sort out the pure types from

the mixed ones of any given generation under these circumstances becomes a matter of enormous complexity.

It could be done by inbreeding representatives of the new type and carefully selecting the progeny for a series of generations.

But, in the end, all that would have been accomplished in the case, say, of a Shasta daisy or of a stoneless plum or a sugar prune, would be the production of seed that could be used to disseminate the new variety. And in most cases we are justified in feeling that this would represent an undue expenditure of time and energy for a comparatively insignificant result.

For, as the case stands, even though the new form will not breed true from seed, it may be propagated indefinitely from roots or from the grafting of cions; so that in practice the failure to breed true from seed has little significance.

Probably it is the fact of the relative unimportance that our cultivated plants should breed true from seed that chiefly explains the failure of plant breeders in the past to fix the type of the best known fruits and vegetables and flowers

The same reasoning obviously applies to the newly developed varieties. While so much work remains to be done in the way of developing new types of fruit and flower, the most practiced

experimenters will probably feel that they have not time and energy to spare for the fixing of the new races already developed.

We shall have occasion to call attention to various exceptions to this rule in the course of our subsequent studies; particularly with reference to certain annual plants. Here by "line" breeding for a few generations we may fix the new traits almost as firmly as the old traits are fixed in wild species. Again we shall learn in due course of new hybrid fruits like the sunberry, the Primus berry, and the Phenomenal berry that are fixed as to their chief properties from the very first hybrid generation. But as regards most of the new forms of fruit and flower that we have hitherto described, the rule holds with full force.

RECORDING EXPERIMENTS

Easy Ways to Keep Track of Progress

EVERYONE has heard the story of the distinguished professor who devoted his entire life to the study of a particular species of mite, and who, on his deathbed, regretted that he had not confined his attention to the study of the respiratory organs of this insect, instead of trying to comprehend its entire structure.

This specialist, like many another, felt that he had wasted his energy by attempting to cover too wide a field. He felt that his ten volumes or so on the anatomy of the mite could give but superficial treatment of a great subject.

Whoever sympathizes with the attitude of mind revealed by this doubtless apocryphal yet truly symbolic tale, will have scant patience with my method of plant experimentation. For, far from confining attention to a single species, or even to a single genus or order, I have extended

my observations to almost every known form of plant, testing species by thousands, and individual specimens by hundreds of thousands or millions, on my experimental farms; and only by exception has complete record been kept of all details of any given series of experiments, beyond the more or less fallacious records of memory.

Yet I have had the good fortune to produce more and more valued forms of plant life that could justifiably be called new than have been produced by any other single experimenter in all time. Had I stopped to make meticulous record of each experiment, I doubt if I should now know as much as I do about even my less important products, and surely should have been able to produce only a fraction of those that I have produced.

Methods and Results

Yet it must not be supposed that I have altogether refrained from graphic recording of the progress of these tests. The fact is quite otherwise. I have kept in the aggregate a vast body of carefully made records, and have had them always at hand, under my eye from day to day, telling of the essentials of all of these experiments.

My "plan books" have been a constant aid to memory and guide to further effort.

My record books have set down in black and white the unequivocal evidence of progress—or of failure to progress. Few salient facts as to the precise parentage of important hybrids and the exact methods by which variation has been brought about have failed to find most explicit record, notwithstanding the omission of multitudes of *details* that to some observers might have seemed worthy of transcription.

And if I have adopted in the field short-cut methods of recording selection, these have not lacked precision and accuracy, notwithstanding their time-saving character.

In point of fact, all along the line I have endeavored to strike a happy medium between the waste of time that would result from the keeping of unduly elaborate records and the waste of effort that would necessarily result if no records at all were kept.

The reader who would clearly comprehend the nature of the compromise must bear in mind that I have, as a rule, had a practical object in view in conducting my experiments. It is true, as Professor Bailey has said, that I constantly make experiments with plants for the mere love of the work. It is true also that my tests include hun-

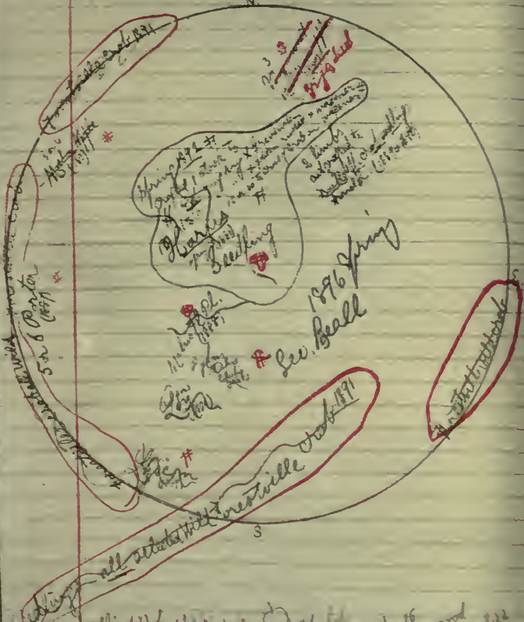
AN EARLY DIAGRAM OF TREE GRAFTS

This is a leaf from one of my first plan books. It is a sort of shorthand or diagrammatical record that condenses a large amount of information into small space, leaving room for additional records should they be called for. Such a page seems cryptic to the casual observer, but to the owner it is full of meaning.

~~New Seedling Peaches Jan 10th 1891~~

Home Gravenstein Tree.

Mar 10th 1891



Seedling ... x ... white bloom

Seedling

American Queen Plum. Exquisite flavor ripe July 25th
seedling of Robinson. two weeks earlier. 2 or 3 times larger

dreds of species from which I expect no very definite return. Yet it is further true that the main body of my experiments have been always concerned with flowers or fruits that seem to offer opportunities for practical improvement.

I have usually been seeking, in the experiments to which most time has been given, to modify the plant in such a way as to make it a more beautiful and desirable garden ornament, or to modify a vegetable or fruit in such a way as to make it a more valuable food product, or a tree to make it produce better fruit, nuts, timber, or some valued chemical product.

Such being the case, it will be understood that, with regard to large series of experiments, I have been concerned with results rather than with methods. As to the latter, it often happens that numberless experiments might be described in substantially the same terms. Once the principles of combination and selection have been clearly mastered, they may be applied to almost every variety of plant life. There are differences in the detail, but the broad outline is the same for each.

Essentials Versus Nonessentials

It would then be but a foolish waste of time to record over and over details as to these broader outlines of plant experimentation. Where any-

thing of interest has appeared, any point as to which a plant shows differences from its fellows, this has become a matter for recording.

Moreover, it has been my universal custom to make record of the first hybridizing or crossing through which any particular series of experiments is inaugurated. The parentage of the Shasta daisy, the white blackberry, the stoneless plum, the sugar prune, the plumcot, the thornless blackberry, the spineless cactus—these are matters of clearest and most unequivocal record. The results of the first crossing, through which matters of prepotency and of latency are determined, and through which the plant is given the impulse to variation, are also explicitly shown.

But when, particularly in case of a fruit having complex characters, the experiment passes to stages of the third and fourth generations, involving tens of thousands or hundreds of thousands of seedlings, it is no longer possible to make detailed and explicit record, with exact count of the different combinations and variations developed, for two very explicit and sufficient reasons.

One reason is that the numbers of seedlings involved are so great that it would be physically impossible for anyone carrying on hundreds of different series of experiments at the same time

to make numerical count in accordance with the statistical method adopted by workers who are experimenting on a limited scale.

The second reason is that even if such a count, showing the exact number or percentage of seedlings with different combinations of traits, were attempted, it would be unavailing unless vast companies of seedlings were preserved for the term of years necessary to bring them to fruitage.

When one is concerned solely with numbers, or with such tangible qualities as color of hair in the case of Professor Castle's guinea pigs, or color of feather with Professor Davenport's fowls, it is an easy matter to check results, because the creatures under investigation manifest the qualities that are being tested from the moment of birth, or develop them at a very early age.

But with plants the case is obviously different. Whereas we may judge something as to the character of fruit that a seedling will ultimately bear from observation of the seedling itself, yet for purposes of scientific record such predictions would be considered as worse than worthless. To know what percentage of seedlings of a given generation have really progressed toward the ideal of a sugar prune that will ripen in August instead of September let us say, it would be

necessary to let all the seedlings grow for several years, or at the very least to wait two or three years for the grafted cions from each seedling to come to fruitage.

The practical experimenter, seeking results, cannot possibly work in this narrow way when he works on a large scale.

He must be content to select from among thousands of seedlings the one or five or ten or fifty that appear to him most promising. To these he must pin his faith, and all the rest must be destroyed to make room for other plants.

Otherwise he would require not sixty-five acres, which make up the total area of my experimental farm, but hundreds or even thousands of acres.

And to keep track of the multitudinous seedlings would require the aid not of the ten or a dozen or so assistants whose cooperation makes my experiments possible, but of a small army of equally industrious workers.

Systematic Work Imperative

But, having thus outlined the limitations that necessarily attend work conducted on a large and comprehensive scale, let me now proceed to elaborate somewhat the other side of the story.

Let me outline the various practical methods of recording experiments that have been devel-

oped in the course of my years of experience, and in particular to point out some of the short cuts that have made it possible to record the essentials, and even in important cases the details, of progress, with a minimum expenditure of time and labor.

Among the essentials that cannot be overlooked by any systematic and successful experimenter are the following:

A general plan of the ground occupied by all the experiments must be made, and there must be clear record of each plant, shrub, or tree planted. It is important also to record the time when each one was grafted or budded; the date of all experiments in crossing any particular tree or plant; observations as to any anomalies of development; and finally, as a matter of course, the results obtained.

As to these things, the memory, no matter how tenacious, must prove more or less untrustworthy. It is only the black and white record that can be depended upon. But plans may be outlined so simply that all these essentials may be recorded at the expense of very little time or labor.

It is not much trouble, for example, to keep a plan book at hand, each page of which is devoted to a certain planting, its location on the grounds, and all other matters that are worthy of record.

RE-SELECTING SELECTED CACTUS SEEDLINGS

The selection of cactus seedlings, in the course of the experiments leading to the development of the new Spineless Cactus, was one of the most arduous tasks ever performed. My hands were never free from prickles for months together, and the pain suffered was almost intolerable. But ultimate success compensated for the disagreeable experience.

It will facilitate matters to have the records of planting arranged somewhat in the order in which the plantings have occurred during the season.

If these records are made on large sheets of paper so plotted as to show the location of the various beds of plants, this will be an added convenience, as it will enable any particular lot of plants to be located, even if the label stakes which are an absolute necessity, have been removed or lost by careless workmen.

Often when planting in the field, letters or numbers are used on the stakes, corresponding with similar letters or numbers in the record book.

Label Stakes and Labels

As to the label stakes themselves, the ones that I habitually use for general field culture are about 20 inches long, 2 inches wide, and ¾ of an inch in thickness. They are smoothly planed and painted about half way down on both sides with common white lead paint.

One coat of paint is far better than two, for if a pencil is used the lightly painted surface takes the lead to advantage, and by bearing down heavily with the pencil, indentations are made in the wood that will resist the weather more effectually and thus give greater permanence to the record.

It is desirable to make the label stakes of soft, smooth redwood or other durable wood. In the East the locust is an excellent substitute. It is advantageous to dip the lower end of the stake in carbolic acid or in a solution of sulphate of copper to prevent decay. These stakes may be used over and over again for many years, being planed off as the occasion requires and repainted.

Many thousands of these label stakes are used each season on my experiment grounds. For smaller beds I use a stake usually 1 inch wide, from 1/8 to 1/4 of an inch thick, and from 10 to 14 inches in length. These smaller plant stakes may be purchased of dealers, and are prepared for use in the same way as the larger ones.

For use on trees a special label is employed, to make records of budding, grafting, and variation. This label is usually 5 or 6 inches long, and from 3-16 to 1/4 of an inch thick. It is notched on both edges at one end and attached to the branch of a tree with a piece of pliable galvanized iron wire. The wire should be loose enough to avoid any danger of strangling the branch.

The labels are painted with white lead. They sometimes remain upon the trees for five, ten, or even fifteen years. To inscribe these permanent labels, I use a thick black paint, composed of a

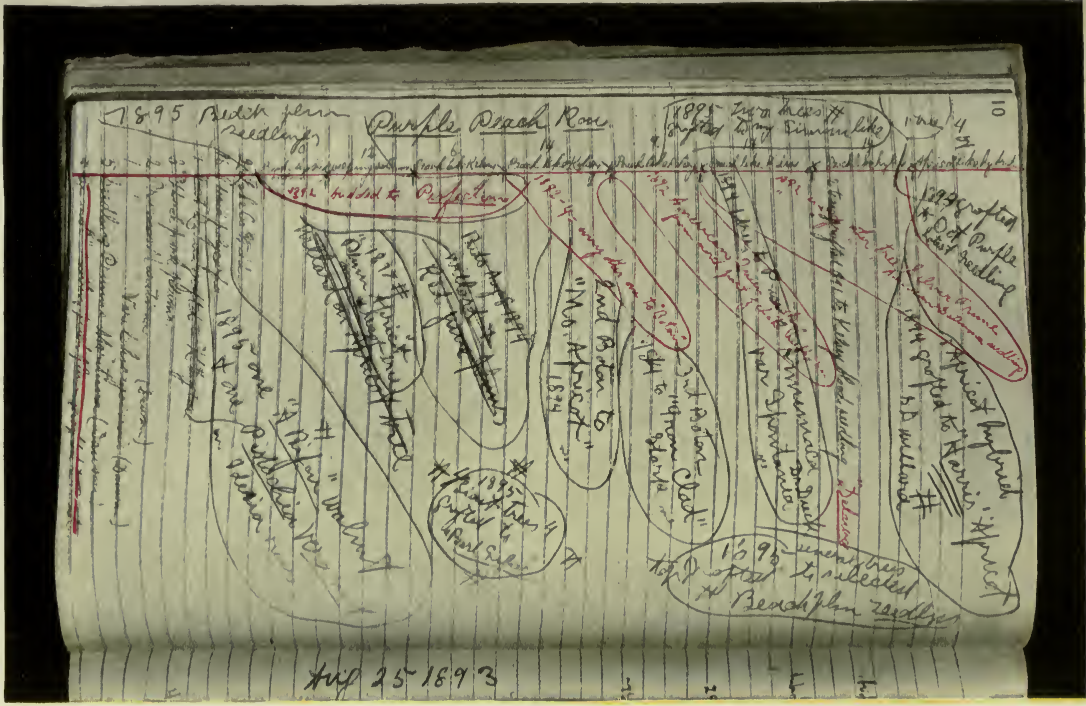
mixture of lampblack, linseed oil, and a little turpentine, applying the mixture with a small camel's-hair brush. The names of varieties, the parentage, and other important matters are thus recorded. Then, while the paint is still wet, some fine dry sand is sifted over the label so as to protect the paint from the weather.

In addition to the labels and stakes I have just described, a small cardboard label of light weight is needed for making record of the hybridizing experiments. The common cardboard shipping tag about 1½ inches by 3 inches in size with a reenforced eyelet hole, is generally used on plants with tender stems; and where the wind is likely to disturb larger labels, half or two-thirds of the cardboard may be cut off, leaving barely space to inscribe the record.

Where these tags are used in extensive pollinations of many varieties on a single tree, it is not always necessary to write the record, for the same object may be accomplished by cutting off one corner of the card to indicate a certain variety of pollen, and a second corner to indicate another variety; additional varieties being represented by series of notches. Or the same end may be attained by punching holes in the card with a pocket steel punch. This plan saves much time, and the record is more permanent than if it were

GRAFTING RECORD

Another page of our older record books, this one also dealing with grafting. It will be seen that the records of different years are associated, and it will be obvious that the records were intended for our own eye, to supplement the records of memory. When thousands of experiments are being performed simultaneously, it is imperative that the recording should be done with the least possible loss of time.


10
1895 Reddish plum seedlings
Purple Peach Row
1895 Two trees # grafted to my Simmons like
1 tree 4
1892 budded to Perfection
1892-4 many this one to Botan
1892 American [illegible] from [illegible] fruit [illegible]
1895 grafted * Oct Purple best seedling
Apricot hybrid
1894 grafted to "Harris" Apricot #
S D Willard
2 trees grafted 1894 to Kelsey Hood seedling "Delaware"
1894 [illegible] Simmonsia
par Spontania
Dr Duck
1st Botan
1894 to "Iron Clad" Stark
2nd Botan to "Mo. Apricot" 1894
1895 several trees top grafted to selected Beach plum seedlings
Aug 1894 Willard [illegible] Red June
1897 # Apricot Plum [illegible] tree Willard on Apricot
1895 4 trees grafted to [illegible]
1895 one "A Rifor" walnut # + one Pistachio ver. Idaho
Aug 25 1893

made with pencil. A large number of tags may be prepared at once with punch or scissors.

Tags of this character are less likely to have their records erased by wasps and hornets, which often partially destroy labels when securing material for their paper homes.

Conspicuous tags such as these are also of aid later in the season when the seed is to be gathered; because they make known at a glance the facts as to parentage, and make it possible to keep separate the seeds of different varieties. The labels are tied to the plants with common twine, as wire or other hard substances would be likely to injure the tender stems when the wind moves the tags about.

When numerous varieties of plants are grown in a single bed, we often nail a common tree label opposite each row on the board that borders the bed, instead of using a stake, as there is less danger of the label being displaced. It will be advantageous to place this label at the side of the bed away from that from which the prevailing winds and storms come. In this section of California the summer winds and winter storms come from the south, east, and southwest, and in conjunction with the hot sunshine they are very destructive to paint. So it is advantageous to face the labels toward the north.

All of these are matters of minor detail, yet not without their importance.

Recording Results

In making selection of individual plants that are to be preserved, or from which seed is to be gathered, the most convenient and at the same time the most accurate method is the simple one of tying a small strip of cloth or string about the stem of the plant.

Visitors to my gardens are sure to notice that each bed of flowers has a half dozen or so plants that are thus decorated. In some cases two or three strings may be attached to a single plant, indicating degrees of excellence. Selection having been made in this way, the plants may be allowed to ripen their seeds, and in due course the workmen may gather them without further direction, placing them in labeled boxes to be stored for the winter.

As regards new fruits, there is particular need of great accuracy, and here it is impossible to avoid a good deal of detail. It will not do at all, in dealing with a valuable addition to the list of fruits, to leave anything to memory as to its season of ripening, size and form, color, flavor, aroma, size of core or stone, length of stem, or any other essential quality.

An exact record must be kept of these items, and for this purpose a book with removable unruled leaves is the mcst satisfactory.

The fruit should be cut in half with a sharp knife. The incised surface may then be placed directly on the paper, and the outline of the fruit traced with pencil. The specimen may similarly be outlined in cross section. This preserves a graphic record of the exact size and form of the fruit. The main character of the inside of each fruit may be indicated, and by adding the date of ripening, the time of its earliest and medium ripening, the number of days it will remain in good condition upon the tree, its keeping quality when packed for shipment, and its susceptibility to the ravages of insect pests and fungoid disease, we have on a single sheet a fairly complete and very valuable record, together with a graphic representation of the form and size of the fruit itself.

Record will be made in the same way in successive seasons of fruit from the same tree, with additional record of the appearance of any new characters or qualities. Comparison of the records will show whether the fruit on the young trees has increased in size, improved in quality, or varied in time of ripening from year to year. Not unfrequently the record of the third year

RIPENING RECORD

This page records the highly important matter of the time of ripening of various fruits. This particular page shows, among other things, that a seedling Japan raspberry ripened April 25, and a new hybrid blackberry May 1. Our finest new fruits, including the Burbank cherry and the Sugar prune are made doubly valuable by the fact that they ripen earlier than similar fruits of other varieties. We can, by selective breeding, modify or lengthen their season of fruiting.

1891.

Fruits Time of ripening

Ap. 15. A Seedling Japan Raspberry (but 1st [illegible]) April 15
May 1. "The New Hybrid" Blackberry May 1st.
" 5 Parker Earle Strawberry

May 25 "The new hybrid" about 1/4 of the crop ripe 2nd crop
well in bloom.
A few (3 to 5) seedlings of Rasp Raspberries commencing to ripen
also a few (3) of 2. Red &c on Aughinbaugh
and 2 seedlings Japan
Aughinbaugh will begin to turn red soon
Everbearing Dewberries nearly out of bloom
Lawton &c just in the full midst of bloom
Raspberries generally nearly done blooming
Japan Crimson berries & [illegible] gone
[illegible] last bloom a week ago.
The Hybrid blooms with Lawton
Seedlings of same time generally.
[illegible] bloom as Lucretia
Wineberry just well commenced to bloom.
Wild [illegible] Natchez blooms with Lawton &c.

June 21 Half the crop of the "New Hybrid BB" picked today. Blossoms
also and buds. Berries weigh exactly 5 to an oz. ###
Photograph of bush taken.
Most Blackberries & Raspberries nearly out of bloom
several seedling Raspberries ripening and a berry or two
on a plant or two of the seedling [illegible]
several bushes of 12 on Aughinbaugh have ripe berries
[illegible] Blackcaps will begin to color

June 10 Juglans Nigra [illegible] not in full bloom till the 8th; [illegible] receptive. May 5th [illegible] Juglans Regia
May 10th My Hybrid. May 15 [illegible] walnut

shows a very considerable increase of good qualities over the first.

After a record has been kept for four or five seasons, a fair estimate may be made of the general value of this particular fruit. If in addition we know the characteristics of the parent forms—whether the ancestors were hardy or tender, and the like—we are now in position to form a clear judgment as to the probable value of the fruit.

Such a record as this is absolutely essential to actual progress. It is important, if for no other reason, to prevent the experimenter from deceiving himself. It is very easy to imagine that a certain product that has caused one much trouble is better than some other; or that a fruit of a given tree is larger than some rival variety. But the record book enables one to put the matter to a precise and definite test; it makes self-deception impossible; and it affords an invaluable guide to further experimentation.

There are thousands of graphic records such as these on the shelves of my extensive library.

I would not think of attempting to conduct an intricate series of experiments for the development of a new fruit without these plan books.

When the experiment is finally completed, a series of these loose leaves, properly collated,

furnishes a complete record of the various hybridizings and selections — resulting sometimes in better and sometimes in worse fruits — through which success has finally been achieved. These records are in themselves sufficient answer to anyone who imagines that the plant experimenter works haphazard, merely because he does not always adopt a biometric method.

After all, from the standpoint of the consumer who makes up the main bulk of the population, and whose tastes and needs are the criterion by which the plant experimenter's results will be judged, it is the final product rather than the precise method by which it is attained that is most important. But the ideal at which the plant experimenter aims would probably never have been realized had he not given himself the aid of some such system of quick and accurate records as my plan books present.

Once the principles of hybridization and selection have been clearly mastered, they may be applied to almost every variety of plant life. There are differences in detail, but the broad outline is the same for each.

FINAL SELECTION

The Most Important Task of All

IN SOME farming districts of the Mississippi Valley they have a curious custom in selling cattle at auction. They drive a herd of cows together and the auctioneer asks his audience to bid for first choice, no individual animal being specified.

The highest bidder makes his choice, and the animal he selects is taken from the herd.

Then the auctioneer starts over, receiving bids for "first choice" among the remaining animals. This process is repeated again and again until all the exceptional animals have been selected.

A curious result of the method is that it very commonly happens that different bidders have their eyes on different animals. Farmer A, who bid highest at the outset, did not have in mind the animal for which farmer B was bidding. And so it often happens that after six or eight selections have been made an animal still remains

that was regarded by some of the bidders as the very best one of the entire herd.

A man who bid unsuccessfully again and again may thus, in some cases, finally have his choice precisely as if he had made the highest bid at the outset.

The obvious explanation both of the method and of its somewhat anomalous results is found in the fact that individuals differ in their judgment as to what constitute the superior qualities of an animal. Each bidder has noted an animal that particularly appeals to him, and each is backing his own judgment in making selection. The result is a process of elimination that may or may not select from the herd the best animals at the very outset.

"But what have animals and their selection to do with the development of new varieties of plants?" you ask.

Nothing direct and obvious, to be sure. But it has often occurred to me that the process of selection at the Iowa auctions is closely comparable to that which is employed by the plant experimenter in the course of his everyday work. In lieu of a herd of cattle, he deals with a group of seedlings. But his task is precisely like that of the auction bidder in that he must select from among hundreds of plants of the same kind, and

often of closely similar appearance, the one that seems to him the choice of the entire lot; and then in succession the second and third and fourth best, until he has chosen possibly six or eight individuals out of a group of hundreds or thousands.

These six or eight individuals will be preserved for use in further experiments. They are the ones with which the attempt to improve the variety to which they belong will be carried out.

And the ultimate success of the entire experiment in plant breeding will very largely be determined by the perspicacity with which the selection of these few individuals was made. Nor can we doubt that it must often happen, in the case of plant seedlings as in that of the cattle, that after the final selection has been made there remain, unknown to the experimenter and in contravention of his judgment, better plants among those rejected than any one that he has chosen.

It could not be otherwise when we consider the large numbers involved, the variety of plant characteristics, and the great diversity of traits represented in a single generation of hybridized seedlings. Yet, on the other hand, experience should enable the experimenter to choose with a relative degree of certainty, and it is possible to

acquire a degree of skill, based on careful observation of the minute details of plant structure, that will give full assurance of a capacity to select with at least a large measure of success.

A Half Hour in the Orchard

It is usually a surprise to anyone who comes to my orchard at a time when I am making selections among seedlings of many kinds to observe my method.

Many people have expressed astonishment when they have seen me walk rapidly along a row of plum trees saying: "Kill this one, and that one, and that; save this one, and that one yonder"; indicating the choice between plants to be saved and those to be destroyed so rapidly that the two or three men following me can scarcely tie strings to the selected ones as fast as they are chosen.

In this way I may test from five to ten thousand young trees as I walk along the row, scarcely pausing for more than what seems the most casual glance. But my eye takes in the important thing. I know just what I am looking for. And if my judgment in the matter had not proved in the main good, the output from my experiments would have been quite different from what it has been.

I may recall by way of illustration an experience in which my selective judgment was put to a practical test—no different a test, to be sure, from thousands that I myself have made, but having added interest because it was made by another.

It chanced that a well known judge, who is also a horticultural enthusiast, and who had been very much interested in my work, was visiting at a time when I was sorting out plum trees from among a lot of several thousand seedlings about a foot high. I had a man placing armfuls before me and carrying them away as fast as selected. They were thrown in three piles, the first containing those I had declared to be the best ones for continuing the test; the second pile containing those I thought possibly worth trying; and the third pile those that seemed to me no good at all.

The judge watched me for a few minutes and then said: "You are picking them altogether too fast. You cannot possibly tell like that which are good and which are not."

I replied: "Wait and see, or test the matter for yourself if you wish."

"Very well," said my visitor, "I will do so."

And therewith he took a few seedlings from each of the piles for the test.

Of course it was necessary to wait two or three years for results. But when the time came, the judge very cheerfully admitted that I had been absolutely right all along the line. The cions from my discarded pile in every case bore fruit that was almost worthless; those from the intermediate pile produced varieties of good fruit; and from the pile of my first-choice seedlings fruits of such quality were produced that he named it the Klondike tree, declaring that it gave him more good plums than he had ever seen before.

I cite the incident as showing the possibility of gauging fruiting qualities of a seedling at a time when the plant itself is a mere sapling a few inches in height. The capacity to make such selection has sometimes been spoken of as intuition; but it is really a matter of observation and practice. One learns through long experience to judge what characteristics of the seedlings are suggestive of possibilities of fruit bearing.

And after all this is no more than judging the man of the future by observation of the child of to-day.

The Correlation of Parts

If we were to state the matter a little more technically, we might say that such selective judgment as I have just illustrated is based on a

knowledge of the correlation between the different parts or members of a plant's organization.

It was first prominently brought out, I believe, by the French naturalist Cuvier something over a hundred years ago that there is always a correlation between the different structures of a given animal, to accord with its habits of life. For instance the teeth and claws of a cat are associated with its carnivorous habits and are linked with a certain structure of legs and muscles adapting the creature to spring forward with great celerity upon its prey.

A somewhat different structure of body and limb is associated with the talonless feet of the dog tribe which are adapted to rapid running for prolonged periods rather than to sudden leaping and clutching.

It was by careful study of the correlation of parts, of which these are only crude and familiar examples, that Cuvier was enabled to gain an insight into the characteristics of fossil animals of which only small fragments of skeletons were preserved in the rocks. The science of comparative anatomy was the outgrowth of his observations.

Now it is at once obvious to anyone who studies plants attentively that their structure also shows a corresponding and no less invariable

correlation of parts. The more conspicuous illustrations of this are obvious to the most casual observer—various adaptations of form of tree and shrub and vine to their natural surroundings are so patent that they cannot escape attention.

But of course the plant experimenter must deal with correlations of a very delicate order. He is called upon to make nice distinctions between individual seedlings of the same variety. All will have the same general formation of stem and leaf. He must look, then, for details of variation that would altogether escape the notice of the untrained observer. But that such differences exist, and that they are signs that to the practiced eye are of the utmost importance, any successful plant experimenter can testify.

It would obviously be futile to attempt a detailed description of the nice shades of distinction between various seedlings of the same race upon which the plant experimenter depends in forming his selective judgments. That, clearly, must be matter for practical observation. It can be learned nowhere but in the field. But perhaps two or three illustrations may be given that will at least serve in a general way to suggest what manner of traits are taken into consideration in choosing the individuals with which he is to continue his experiment.

A Few Practical Hints

In selecting raspberry or blackberry plants for color of fruit, for example, there is almost always a correlation of the plant and fruit that will foretell the future crop.

I have observed in thousands of instances that vines that have purple spines and canes will in future produce berries that are dark purple or dark red in color. Pinkish leaves, on the other hand, foretell fruit of light pink or red color; plants with yellowish vines and foliage may be expected to produce berries of a yellowish color. Very pale foliage and canes usually indicate that the crop will be of a whitish or amber color.

A knowledge of this correlation between vine and fruit was of great service to me in my later experiments for the development of the race of white blackberries. It enabled me to select for transplantation and particular care vines that would produce the type of berry sought. It was not necessary to await the time of fruiting in order to gauge progress.

The correlation of characters between the vine and the fruit of the grape is not always quite so clearly established, yet it is often observable. Grape tendrils may give clear indication of the size and flavor of the future bunches of fruit.

Long before a grape vine has come to the age of fruiting, the taste of the tendrils may give a fair idea of the flavor of the grapes it will ultimately bear.

Moreover the seedling vines that produce bushy stems that are small and much branched, and have small leaves, will almost invariably produce meager clusters of small fruit of poor quality. So the wise experimenter will root out such vines without letting them come to maturity.

Among plums and peaches the correlation of characters is exceedingly valuable.

The case of the plum seedlings already cited suggests the possibility of prejudgment of fruit from observations of small seedlings. There are a good many characters of leaf and twig that are almost too intangible for description, like the changing expressions of the human face, or like delicately graded colors, yet which to the practiced eye are full of meaning.

Color of Foliage a Guide

A broad general distinction that is fairly obvious to any observer is found in the color of the foliage. It may be expected that a plum or peach seedling having foliage of a reddish purple color will produce fruit dark-colored not only in skin but in flesh. And of course the selection

made from any given lot of seedlings will depend largely upon the particular qualities that one desires to develop.

But, as repeatedly pointed out, in practical work one is usually looking for a combination of qualities; and, by the same token, one usually inspects his seedlings for the combination of characteristics of stem and leaf and color. He seldom has his choice determined by a single characteristic, obvious or otherwise.

Selecting for a Single Character

Yet there are cases where an experimenter is working with a single plant characteristic in view, as, for example, when I successfully attempted to develop fragrant callas and dahlias and verbenas.

Here, obviously, the task of selection is comparatively simple. We are dealing in each case with a flower that has certain desired qualities of color that are firmly fixed in its heredity. The one conspicuous point of variation among thousands of specimens is the presence or absence of a pleasing aroma.

It is necessary, then, merely to select the individual plants that have the most pleasing perfume and to use these only for carrying on the experiment. By making such selection

ROSE CUTTINGS—DEVELOPED BY SELECTIVE BREEDING

A new variety of rose—developed by selective breeding—may be propagated by merely cutting the branches into sections and planting them in light, well-drained soil. It is, of course, necessary to have at least one bud, and preferably two or three on each cutting. We have developed some very remarkable new varieties of roses, including one that received a gold medal at the St. Louis International Exposition in 1904, *as the best bedding rose then known.*

generation after generation, choosing always the sweet-scented and rejecting the others, it proves possible to accentuate and fix the quality of perfume production without altering the other characteristics of the respective flowers in question.

Again the quality sought may be a particular color of blossom, and it may be desirable to pay attention to this only, practically disregarding all other qualities. Such, for example, was the case with my experiments with the crimson *Eschscholtzia,* commonly known as the California poppy.

The blossoms of the plant from which this new type of poppy was developed had a narrow stripe of crimson on the inner side of one petal.

This was an anomaly that appeared "spontaneously." Doubtless it was due to some crossing of ancestral strains that brought out a latent character that had long been suppressed. But as to this we can only surmise. The simple fact of the matter was that a blossom did appear that had this narrow stripe of crimson on one petal. I seized on this individual blossom as offering material for an experiment in color variation.

Seeds from this plant produced the next year several plants that had a trifle more crimson on their blossoms.

The following year there was still further improvement, as plants appeared that showed a much larger invasion of the flower petals by the crimson coloring. And by selecting year after year blossoms that showed this increasing tendency to adopt the new color, I produced presently a plant that bore blossoms of a beautiful uniform clear crimson. No trace of the original yellow color remained.

This furnishes a very good illustration of selection for color where the material consisted of a small stripe of an unusual color appearing on blossoms otherwise of a fixed hue.

But the same method of selection may sometimes be applied to the improvement of the shade of color, or even to the development of a new color, from a flower that shows only a faint departure in shade from the normal. And the same principle of selection, followed out in precisely the same manner, applies to the development of flowers or fruits of varying size, of larger or smaller stem, abundance of blossom, profusion of leaf or flower or fruit, and the like.

It is equally possible to alter the proportions of the chemical constituents of a plant in certain instances.

The case of my Sugar prune, the fruit of which was developed to have a sugar content of

more than 23.92 per cent, nearly one-fourth sugar, as against the 15 per cent of its ancestral type, will be recalled. In a similar way the sugar beet has by mere selection been developed until the races now cultivated contain several times the proportion of sugar of the ancestral beets even of twenty years ago.

An interesting experiment in causing the progeny of a certain plant to vary in opposite directions through selection, has been made at the Illinois Agricultural Station. Here the quality under consideration was the protein content—that is to say the amount of nitrogenous matter—in the kernels of a given variety of corn.

The specimen with which the experiment started showed on analysis 10.92 per cent of protein. Selection was made, among the ears of corn grown from this seed, of the individual specimens having the highest protein content on the one hand, and those having the lowest protein content on the other.

By continuing this double selection for ten generations, two races of corn were developed, one of which produced seed having an average protein content of 14.26 per cent, while the other, grown in the same field, showed a decrease to 8.64 per cent.

This and similar experiments illustrate the possibility of selecting out and fixing new races varying widely as to a single important quality of grain among the descendants of a parent plant of relatively fixed strain. In fact no plant is so fixed that its individual members do not show variation; none so fixed that it does not supply material with which the experimenter may work in producing new varieties.

Another illustration of the same thing was given by an allied series of experiments at the Illinois Station at which selection was made with reference to the height of the ear on the corn stalk. Seed from the same cob was planted in two fields and grown always under closely similar conditions.

But in one field selection was made for breeding purposes from stalks having the ears higher from the ground than the average; and in the other field from ears that were lower than the average. At the end of five years the two fields were so widely diversified that the average height of the ear from the ground in one of them was less than three feet (33.2 inches), whereas in the other field the average height of the ears was fully six feet (72.4 inches).

One could not well ask a more striking illustration than this of the possibility of developing

new races, differing as to some conspicuous character, by simple selection from a given stock.

The case of my winter rhubarb, which came to have a relatively gigantic stalk, will be recalled as of similar import; although in that case the experiment was complicated by having to bear in mind various other qualities in addition to mere size of stalk. My giant corn and the corn with the wonderful rainbow-striped leaves are other examples.

Some Alarming Figures

But, as repeatedly pointed out, the experiment usually is complicated by the necessity for considering more qualities than one whenever selection is made with an eye to the production of a *commercially valuable variety* of flower or fruit or vegetable, and not merely for the purpose of scientific record.

We have seen this illustrated again and again; and we have seen also how great are the complications which result when we are called upon to make a selection that will give us not merely one quality—merely size or a given color or sugar content—but a combination of six or eight or ten qualities, all in superlative measure.

We have seen that the chance of securing any given combination of qualities decreases at a

startling geometrical ratio in proportion as the number of qualities increase.

The precise formula, as calculated by the biometricians, runs something like this. In case a single pair of qualities is in question—say high protein content versus low protein content in corn—the chances are, if the two strains are crossed, that there will appear in the second generation of their progeny one offspring in four that closely resembles each parent.

But when we are considering two qualities—say protein content and height of ear on the stalk—*in combination,* the chance that there will be an individual of the offspring like each parent in the progeny of the second generation, is only one in 16.

And when three qualities are in question the ratio jumps to one in 64; with four qualities it advances to one in 256; with five qualities, to one in 1,026. When eight qualities are in question, the chance of producing one offspring showing precisely the combination of qualities of each parent is only one in 98,496.

And when we deal with ten qualities we encounter the altogether disconcerting ratio of one to 1,575,936!

All of which makes it very clear that the wise plant experimenter does not depend upon mere

chance to give him the combination of desired qualities in the production of a new form of flower or fruit. He must make his selection, in any given generation, with reference to one or two preeminently desirable qualities, and must be content to accept for the moment such other qualities, however undesirable, as are associated with the desired ones.

Multiple Selection

For example, in developing a stoneless plum, my earliest selections were made with an eye to stonelessness alone.

Then as I gradually developed a race of plums in which I was certain of finding a fair proportion of individuals growing stoneless fruit, I could select among these the ones that combined with stonelessness the largest proportion of other good qualities, such as size, flavor, and abundant bearing.

When presently I had, through selection, developed a somewhat fixed strain that combined the qualities of stonelessness with fair size and good flavor, I could then select among the many individuals showing these qualities the particular ones that showed them in fullest measure; and at the same time I could now have in mind one or two other qualities—say color of fruit and

keeping quality—and be guided in my selection by a consideration of these traits in addition to the others that had already been fairly fixed.

Thus the matter of selection, even when many qualities are to be combined in the ultimate product, is not quite so hopelessly complex as the calculations of the biometricians might lead one to suppose. Yet it is assuredly complex enough to test the patience and the ingenuity of any experimenter to the last degree.

So the amateur who enters this fascinating field will do well to begin with simple cases, paying heed to a single quality of any flower or fruit with which he experiments; endeavoring to advance along one line till he acquires skill to attempt more complex experiments.

Let him, for example, increase the perfume of some familiar garden plant, or develop a race having large blossoms, or one having peculiar brilliancy of color.

Any flower bed will show him, among different specimens of the same species, enough of variation to furnish material for his first selection. And he is almost sure to find encouragement through discovery, among the plants grown from this seed, of some that will show the particular quality he has in mind in a more pronounced degree than did the parent plant.

So here he will have material for further selection, and step by step he can progress in successive seasons, often more rapidly than he had dared to hope, toward the production of the new variety at which he aims.

Of course the time will presently come when the amateur who thus begins with what may be called the alphabet of plant experimentation, will wish to advance to more complicated projects. He will wish to urge his plants along a little more rapidly on the path of variation by means of hybridization.

But even here, as will be obvious on a moment's reflection, the experimenter is still dealing with selection. For of course he will not make his hybridizing tests at random, but will select for his parent stock individuals that manifest in pronounced degree the qualities that he wishes to combine in his projected new race.

So when we pass from the stage of simple selection of "spontaneous" variations to the stage of inducing variations along given lines by crossbreeding, we are not abandoning selection but are only dealing with selection in its more complicated aspects.

Rightly understood, then, it is not too much to say that the entire task of the plant developer is a matter of selection. First, he may select

varieties as nature presents them to him. Second, he may through selective breeding improve these varieties. Next he selects among these and makes combinations for further variations; and then he is ready for a new series of selections. So from first to last it is only the same story presented in different aspects.

How important a part does selection play in the life about us! Whether it be in animal or human life, whether it be the selection of materials for a nest, an appropriate club or stone to lay low an enemy, the selection of materials for a dynamo or a pyramid, or of words to convey certain thoughts, aspirations, or emotions; but selection alone from among all the materials supplied by nature, no matter how skillfully carried out, can never produce the artist's ideal in pigments or marble, the architect's vision of a great structure for the shelter of thousands—universal standards of excellence—unless their production is accomplished by means other than metrical and statistical!

If you really desire to know what plant life will do under certain conditions, why not ask it by careful experiment instead of asking and answering yourself.

The beginning is selection and the end is selection.

HASTENING METHODS OF FRUIT IMPROVEMENT

Specific Needs, and How to Accomplish Them

THAT old pear tree out there in the corner of your garden was perhaps planted by your father's father.

The twig you cut from it to-day may, if placed on the proper root, become a thrifty tree that will bear fruit to gladden the hearts of your grandchildren in the future. And that possibility puts the tree on a very different footing as the friend and companion of man from that occupied even by the most highly prized members of the company of forage plants and garden vegetables.

When you work with fruit trees you are making permanent records. You are building on a rock. You are reaching out your hands to future generations, and erecting a monument that will remain as a testimonial to your foresight and wisdom long after you are gone.

And doubtless this fact of the permanence of the tree accounts in large measure for the interest with which almost anyone will take up the culture of fruits if given the opportunity. Not that we are always thinking of posterity; but one can develop an enthusiasm about the production of something having an element of permanency that does not attach to such transient things as annual or biennial plants.

The fruit tree in the old orchard is like an old friend when we get back to it. The mere view of it brings up reminiscences of our youth, and the tree that we planted in childhood may remain as a stimulus to us in old age.

There is no friendlier compact than that between man and the fruit tree.

It is an age-long compact withal. Not so ancient as the compact of bees and flowers—for as compared with the archaic and honorable order of insects man is a parvenu—but far older than human civilization none the less.

Indeed, it was probably the fruit tree, giving an example of fixity of habitat, that encouraged man to give up the life of a nomad and establish a fixed abode.

Not unlikely it was the evidence presented by the fruit tree that first suggested to man the pos-

sibility of raising a supply of foods from the soil, and thus lured him away from the precarious pursuits of the hunter and fisher and put him on the road to future greatness.

And all along the road of advancing civilization the friendship with the fruit tree has been kept up. Yet it is only in comparatively recent times, probably, that rapid progress has been made in aiding these coadjutors of the pomological world to step forward and better themselves as man had long ago bettered himself with their assistance. To be sure, our forebears developed many forms of fruit that were not lacking in palatability; but the great advances in the improvement of orchard fruits are matters of the nineteenth century.

Recent progress in this field has been almost as wonderful as progress in the fields of mechanics and electricity.

The orchard fruits of to-day that find their way to the markets are so different in size and quality from the fruits with which our grandparents were satisfied—even though some of them are grown on cions grafted on the old trees—as to seem to belong almost to different orders, certainly to different species from the fruit stocks from which they have been developed.

THE WICKSON PLUM

This is a hybrid plum which is grown and shipped by the million pounds yearly. It is the first large, high-quality shipping plum ever produced, and still holds a place near the top in the growers' estimate, though several others which I have since produced are now being more extensively planted. (Nearly natural size.)

Yet what has been done is only the beginning. We speak of "perfected" fruits, and in a sense the word is justified, so conspicuous are the good qualities of the new fruits as contrasted with the old. But no fruit has really been perfected, in the sense of having reached the limits of improvement.

There are numberless opportunities for betterment even in the case of the very finest varieties of fruits of every kind.

The successive chapters of the present volume will be devoted to specific suggestions as to the betterment of each of the important classes of orchard fruits. In the present chapter, it is my purpose to take a general survey of the field, pointing out various lines of betterment not so much with reference to any particular fruit, although we shall constantly draw our illustrations from specific fields, as with reference to the entire class of orchard fruits.

The suggestions here outlined are the result of lifelong associations with trees of the orchard. Probably nearly half of my experiments of every character have been conducted in connection with one form or another of fruit trees.

And a large proportion of my most important new products, considered from an economic standpoint, have been products of the orchard.

As to Mere Size

Almost the first thought that comes to one who goes into the average orchard and looks about with a really observant eye is that orchard trees in general are not well adapted to man's needs in the matter of size.

I have in mind certain orchards of New England and Long Island, for example, in which the apple trees seem to have done their very best to rival the elms and oaks in size. Their trunks and main central branches rise, barren of fruit-producing branches, to a height of twenty-five or even thirty feet.

The strength of the tree has quite too often gone to producing wood instead of fruit. Such fruit as does appear is suspended so high that long ladders are quite often required to reach it.

This is obviously wrong. There is no reason why the apple tree should be permitted to grow high into the air even if it has the inherent propensity to do so. By proper pruning the young tree can be made to assume a spreading form, so that it will bear most of its fruit within easy reach. Moreover, it is easily possible through selective breeding to develop an apple stock that will have no tendency to grow into tall, or otherwise ill-shaped trees, but will naturally take on

the compact, low-growing habit that is to be desired in a fruit tree.

What is true of the apple is equally true of its cousin the pear. This tree also has been permitted in the old-time orchards to develop the pernicious habit of too slender upright growth and undesirable tallness, too much like a wildling. These defects have been corrected with some of the newer varieties, to be sure, but these have not been introduced universally.

The same criticism applies to the cherry. Everyone knows how often this tree is seen growing in the New England dooryard, with trunk like that of the sturdiest oak, and with its inviting clusters of red fruit suspended at such a height as to be quite beyond reach of everyone but the birds.

A well-trained cherry should renounce this tantalizing habit and make its wares reasonably accessible to the wingless biped that has fostered it.

The other notable members of the company of orchard trees, namely the plum, peach, quince, and orange, have in the main developed a more commendable habit of growth. Their trees are for the most part not too large, and the best varieties have a spreading form that leaves little to be desired. But some of these, and in particu-

lar the peach and orange, have other faults that urgently call for correction.

The peach in particular is a tender and short-lived tree, peculiarly subject to the attacks of insects and to fungoid pests.

Apparently the developers of this luscious fruit have been so concerned in fostering the remarkable qualities of the fruit itself that they have neglected the tree on which the fruit grows. So the peach orchard, instead of outlasting a human generation as it should, is an ephemeral growth, the individual trees of which are generally in good bearing condition only for a few years, after which they must be replaced.

The peach grower has often to uproot the dead trees in one part of his orchard and plant new ones in another.

The Question of Stamina

Unfortunately the peach is so specialized that it will not thrive on any roots except its own. It should be possible, however—at least the project is one that invites the experimenter—to develop a more vigorous and longer-lived race of peaches. Something could doubtless be done by mere selection, taking cions for grafting or raising seedlings from the hardiest and most vigorous trees of the orchard. Probably in successive genera-

tions there might be developed a stock of trees that would retain all the good qualities of the peach and yet would be long-lived, vigorous, and productive.

No very striking commercial results have yet been produced by crossing almond and peach, though many unusually vigorous and rapid-growing trees have been produced which will far outgrow the most vigorous individuals of either species.

But hybridizing, followed by rigid and persistent selection, is a practical method that is still in its infancy. It is not so very long since orchardists in general, supported by most technical botanists, denied the possibility of hybridizing different species.

My long series of varied experiments were perhaps more directly instrumental than any other influence in showing the fallacy of this belief. The reader will recall that I have in many instances interbred species belonging to different genera; and that the interbreeding of different species in my orchards and gardens is a commonplace. Yet it is still true that there are many cases in which there seem to be barriers erected between plants that obviously are closely related, which prevent the advantageous hybridizing or grafting of one species with another.

SANTA ROSA PLUM

This remarkable fruit is considered by the trade one of the four best plums that I have developed. It is an exceedingly intricate crossbred plum, combining the traits of ancestors from three continents. Though of comparatively recent origin, this plum is probably more prized for shipping east than almost any other. It is supremely delicious. Tree sturdy and productive. (Natural size.)

And the peach is a case in point. It accepts the pollen of its nearest relations (except the almond) unwillingly, and as yet no useful product has come of such union.

Yet the peach is not more isolated in this regard than its relative, the apricot, seemed to be until I was able, after many efforts, to hybridize that fruit with the plum. The hybrid that resulted, named the plumcot, is virtually a new species. It combines most of the good qualities of both parents and is a very valuable addition to the list of orchard fruits. It seems not unlikely that some future experimenter will be able to effect a correspondingly useful hybridization of the peach; then the way will be open for the development of a race of peaches that will combine with the existing qualities of fruit production the qualities of hardiness and resistance to disease that the present peach tree so notably lacks.

Big Fruit and Free Bearing

Size of fruit and prolific bearing are characteristics of such obvious desirability that they cannot be overlooked even by anyone.

Yet the average amateur, who has a group of fruit trees in his garden or even a fair-sized orchard on his country place, is content to buy large, handsome fruits in the market, taking it

for granted that his own trees cannot be expected to supply similar products. But in point of fact it is well within the possibilities to produce good orchard fruits wherever the trees exist that produce any fruit at all. Conditions of soil and climate cannot, of course, be ignored. One cannot grow oranges in Canada or grapefruit in New England—as yet. But if you have apple, pear, plum, or cherry trees that bear fruit, it is a matter of your own choice whether they shall bear good fruit or bad.

All that is necessary is that you should send to some reputable nurseryman or orchardist and secure cions of good variety for grafting your trees.

All apple trees are closely related, the cultivated varieties being without exception of mixed strains. The same is true of pears and plums and cherries. In each case you may graft on your native stock cions of any variety of the same species, or a dozen or a score of different varieties, and, if the work is well done at the right season, the new twigs will soon become a part of the old tree as regards vitality and capacity for growth and fruiting; but—as we have learned in earlier chapters—they will retain their inherent hereditary tendencies as to quality of fruit.

Growing side by side, on the same tree, you may have summer apples and winter apples, sweet apples and sour, green varieties and red varieties. And all this without any necessity for experimentation on your part. You need have no knowledge of plant breeding except an understanding of the simple technique of grafting.

The professional experimenters have supplied the material; you have but to avail yourself of the results of their work.

Of course, if you wish to go a step farther there are inviting fields that you may enter. With the materials furnished by a single old apple tree you may become a plant developer. You may plant the seed of any choice apple purchased in the market and from the seedlings you will develop an interesting variety of fruits, some of which may seem to you better than any existing varieties.

We have already caught glimpses, in the outlines of the work already given, of the possibilities of the development of various orchard fruits as to size and flavor and other desirable qualities.

If you desire to try your hand at similar improvement either of the fruit now growing on your ungrafted trees, or of that growing on cions of improved varieties, it will require only reasonable attention to the principles already outlined

in earlier chapters of this work, together with a fair degree of patience and persistency, to insure some measure of success.

There is one additional hint that it might not be amiss to emphasize. In selecting seed for planting, it is desirable, of course, to select from varieties which produce the largest and best specimens. But it should be recalled that the real test of quality in a tree is not the production of exceptional individual fruits, but the size, beauty, and quality of the average fruit that it bears.

Exceptional conditions of nutrition may cause a single apple to grow very large on a branch that as a rule produces only fruit of meager proportions. Seedlings from this exceptional fruit do not inherit the exceptional quality of their parent.

It is the germ of the tree itself that counts. Seed from a very small apple of a good variety will, other things being equal, produce better offspring than the seed of a very much larger individual specimen of a poor variety; so it is far better to select the poorest fruit of a good variety rather than the best of an ordinary variety.

This principle should always be borne in mind in undertaking plant development of any kind, not merely with reference to orchard fruits. It is

the inherent properties of the plant organism as a whole that will determine the average character of the fruit.

Breeding for Quality

As to the special qualities of fruit that call for improvement, details, of course, differ with different species. We have seen that sugar content is an all-important item in the case of the prune; and that sweetness and flavor and color are matters of importance in the case of the cherry. We have also seen with what relative ease varieties may be developed that surpass their parent forms in these regards.

An interesting illustration of the possibility of breeding new qualities into a fruit or accentuating old ones, to which reference has not hitherto been made, is manifested by one of my new cherries, which through selective breeding became so sweet that its sugar content acts as a preservative, quite as in the case of the Sugar prune.

These cherries, instead of decaying rapidly after ripening, dry on the tree in a state of perfect preservation. This particular feature is of no present commercial value, but the case illustrates the possibility of altering the inherent qualities of a fruit, and of doing this in the

course of a few generations through systematic selection.

The same thing is illustrated by another of my cherries which, by careful attention to a combination of qualities that would ordinarily be quite overlooked, had its stem so strongly anchored to the stone that when the fruit is picked the flesh is removed, leaving stem and stone on the tree.

Now it will be recalled that, in the case of the prune, it is a serious defect to have the fruit so firmly attached to the stem that it clings to the tree after ripening. A prune must drop of its own accord when ripe or the commercial grower will have none of it. But the quality that would make a prune commercially worthless, when accentuated in the cherry, becomes a mark of possible exceptional value. The cherry that leaves its stone on the tree might conceivably fill a special purpose. So this variation in the inherent properties of the cherry might produce a new race of commercial value to meet an exceptional need.

It requires but little imagination to suggest possible developments that would similarly give added value to the fruits of various species.

For example, there is the matter of color in the pear. Unlike most other fruits, this one, as everyone knows, is for the most part lacking in

the brilliant color that purchasers of fruit in the market usually find so attractive. But there is no reason why pears of various brilliant and attractive colors should not be developed just as colored apples have been.

Our native crab apple is dull greenish brown or dull red, and unattractive in color even when ripe. Of course, this is not the direct progenitor of the cultivated apple, but it obviously belongs to a closely related strain, and it shows us the apple in a state of nature and gives us a clue as to what qualities of fruit are advantageous to the apple itself, and what ones have been bred into the stock to meet the demands of the fruit developer. So the fact that the wild crab apple is dull in color suggests that the variously pigmented coat of the cultivated apple is an artificial product, not primarily beneficial to the plant itself, that man has developed through selection, just as the bees have helped to make the beautiful colors in flowers.

It is not unlikely that the relatively thin skin of the cultivated apple, coincidentally developed, makes pigmentation desirable, to protect the tissues of the fruit from too much sunlight. The fact that many apples redden where exposed to the sun and remain green where protected by the shadows of a branch or leaf, suggests this.

GETTING COLOR INTO THE PEAR

The ordinary pear, in its better varieties, is as large as can be desired, and its shape is regarded by many fruit growers as ideal. But hitherto the pear has for the most part lacked the color which gives such attractiveness to many varieties of apples. Some of my work has been experimenting, however, in the production of pears with richly colored fruits, as the example at the right shows, as contrasted with the ordinary one at the left.

But be that as it may, the point I wish to emphasize at the moment is that the pigmented coat of the apple has been produced mostly by unconscious artificial selection. There can be no doubt that the pear could be given a brightly colored skin should anyone take the trouble to make the experiment in selective breeding.

Indeed, a few varieties of partly red pears have been developed, and have proved a valuable novelty in the market. Other and better varieties, variously tinted, should follow.

It has been suggested that a globular or apple-shaped pear with a short stem would be acceptable to the packers because it would crate more compactly and carry better than the ordinary pear. But this would rob the fruit of one of its distinctive characters, so on the whole the change would probably not be an improvement. In the matter of size, also, it would appear that the pear, in its best varieties, has attained a maximum development.

To make it much larger would be detrimental, as it would be shaken from the tree by the wind. Even now some varieties are so large that they break away from the tree before ripening, and so these varieties are avoided. The Beurre Clairgeau, one of the best of all pears, is little grown for this very reason.

But in matter of flavor there is still opportunity for indefinite variation. European cultivators have produced remarkably pleasing and varied flavors in this fruit. An illustration of how the flavor of a fruit may be radically modified is furnished by my Apple plum, which, while retaining the characteristic attributes of its race, curiously simulates the apple in the matter of form and color and even in taste and texture.

Another instance is my Bartlett plum, which out-Bartletts the Bartlett pear in its own peculiar quality and flavor. Yet others are the Pineapple quince, which has the flavor and fragrance of the pineapple itself, and the Sunberry, which has the exact flavor of the blueberry.

Corresponding modifications of the pear as well as of all other fruits lie within reach of the patient experimenter.

Leaving Out the Core

But perhaps the most inviting field of all, in connection with the possible development of orchard fruits, is that having to do not with the form or texture or flavor of the pulp, but with the seed of the fruit.

Of course, it must not be overlooked that, from the standpoint of the fruit itself, or rather from the standpoint of the tree on which it grows, the

seed is the only really essential part of the fruit. All of the embellishment of juicy pulp and highly pigmented skin is but the lure for man or other animals put forth by the plant on behalf of the seed, in the interests of self-preservation.

The really essential part of the entire structure is but an infinitesimal cell lodged at the heart of each kernel of the seed.

Indeed, we may, with the aid of the microscope, go even one step farther and say that the nucleus of a single cell, born of the union of the nuclei of two germ cells, is the really important part not merely of the fruit but of the tree on which it grows.

For within the infinitesimal structure of the nucleus, by the most mystifying of all nature's feats of jugglery, are lodged those hereditary factors or determiners that will ultimately transmit the traits of the ancestral tree to the tree of the future.

In the widest sense it is true that the sole purpose of the entire plant is to produce a certain number of these germinal nuclei, each representing the union of a pollen grain with an ovule; each carefully incased in the structure that we call a seed; and each capable of reproducing, with sundry modifications, the characteristics of the parent plant, or, in a profounder view, the

blended characteristics of the entire ancestral race which the plant represents.

When we consider the seed in this way it does not seem strange that all the resources of nature should concentrate on the development of the fruit structure in which the all-important seed or cluster of seeds find lodgment. And by the same token it is comprehensible that nature will hold to the seed with the most unwavering persistency.

And so it is not strange that the plant experimenter should be able to alter the size and texture and quality of the fruit pulp far more readily than he can modify the core or stone.

Yet from man's standpoint this inevitable central structure, forming the heart of every orchard fruit, is a conspicuous detriment. And it is altogether desirable that fruits should be developed in which the stony or fibrous covering of the seed is eliminated, or in which the substance of the seed itself has been substituted by juicy tissues.

Everyone knows that this much desired modification has been effected, or all but effected, in the case of the so-called navel orange. An accidentally discovered mutant, doubtless a pathological specimen, was seized on by some keen-eyed observer in Brazil and has been widely disseminated by grafting. There are also seedless grapes.

The reader will recall the long series of experiments through which I was enabled, by taking advantage of a similar malformation in a wild European plum to develop by hybridization and selective breeding a race of stoneless plums.

Everyone knows, also, that there comes to us from the tropics a familiar fruit, the banana, that is seedless; although perhaps it is not so well known that this fruit has lost its seed through being propagated for long generations by division. The precise steps through which this development has taken place in the case of the banana are not matters of record. But its condition is similar to that of the sugar cane and of the familiar horse-radish in our gardens, both of which have been so long propagated by division that they have abandoned the habit of seed formation. The banana in its wild state was practically filled from end to end with large, hard, bulletlike seeds or stones, with just enough pulp surrounding them to make the fruit attractive to birds and wild animals that could not destroy the seeds. Had not a pathological form appeared without seeds, which must be cultivated solely by division, the banana would be a practically useless fruit to-day.

And, for that matter, the potato furnishes us with an even more familiar illustration of the re-

nunciation of the most primitive and important of all plant functions, that of seed bearing, which has developed under cultivation within the past half century.

But among orchard fruits the stoneless plum is the only example of a plant that has been thus profoundly modified—although a seedless (but not colorless) apple and pear, in the experimental stage of development, have been announced. These examples, however, are stimulative. They show that the possibilities of cooperating with nature are almost limitless; and it is hardly to be doubted that the plant experimenters of the not distant future will carry out the process of making all our orchard fruit seedless and colorless.

As stated before, this is doubtless one of the most important matters that present themselves for the fruit developer. It is a field in which there is room for all and the allurements of which should prove inviting to a vast number of workers.

When you work with fruit trees you are making permanent records —reaching out your hands to future generations—erecting a monument that will remain long after you are gone.

SOME PRACTICAL ORCHARD PLANS AND METHODS

How to Begin and Carry On the Work

"WHAT kind of a tree is that?" asks a neighbor as he leans over the fence. "Why, it is hardly fair to speak of that as a tree; that is a concentrated, double-barreled prune experiment. If I were to name all the varieties of fruit that are growing on the branches from that single trunk, it would sound like reciting the names from a nursery catalogue. Nearly all my important experiments in developing a particular variety of cherry, plum, peach, apple, almond, nectarine, quince, apricot, nut or timber tree are made, at one stage or another, in these tree colonies."

And when my questioner, observing now on closer inspection that practically every branch shows evidence of having been grafted, inquires what will be done next season, I explain that a large proportion of the present branches will be

cut away and grafts from other seedlings put in their place for further tests.

The usefulness of a tree as the basis of further experiments is not finished by any means when it has once been covered by grafted cions. The same process may be practiced over and over for twenty years or more.

Doubtless no other observation made even by experienced fruit growers is matter for greater surprise than this utilization of single trees for the carrying out of vast numbers of experiments. The utility of the method, in the saving of both land and time, is altogether obvious when once attention is called to it. Yet few, even among professional fruit growers, have hitherto gauged the possibilities of the method.

Of course, the average person who inspects my farms has no thought of becoming an experimenter on a large scale and there would be no occasion to practice multiple grafting and re-grafting on any such scale as that employed at the Gold Ridge farm. But I call particular attention to this matter of fruit-tree grafting, because there is a lesson in it not merely for the commercial grower of fruit, but for tens of thousands of persons scattered across the length and breadth of the country who have in their gardens a few fruit trees, at present of no apparent

value, that might be made to bear good fruit in abundance.

Moreover, there are other thousands who have on their farms neglected orchards, run riot with weeds and bringing no monetary return whatever, which might be made the most productive and valuable portions of the entire acreage.

And in each case the grafting of good varieties of fruit on the old and otherwise worthless stock is the key to the entire situation.

Old Trees Made Young

We shall have occasion in the successive chapters to examine in detail the methods of cultivation and possibilities of improvement of the different orchard fruits. Here it may be of service to take a brief general view of the subject. And at the outset I wish to emphasize the possibility of making over the orchard material which is now in hand, so to speak, and which is being so often neglected.

Reports from all over the country tell the same story. In Ohio, for example, according to the report of experts of the Agricultural Station, there are thousands of acres of idle orchards. The production of apples—the chief orchard fruit—has fallen to less than a fourth of what it was a generation ago. Apple trees themselves are

about half as numerous as they were; and this implies that those that remain are only half as productive as the trees of twenty-five or thirty years ago.

Such a record, coupled with the fact of an ever-increasing demand for orchard trees, seems almost incomprehensible. Yet similar reports might be had from other regions where fruit production was formerly a more or less important industry.

But fortunately the facts of the situation are now being called to the attention of the general public, in particular by the workers at the agricultural experiment stations. Bulletins are being issued that call attention to the possibilities of rejuvenating the old orchards, and in many regions results of this work are being manifested in the restoration of these abandoned orchards. In one county in Ohio, in a recent season, 117 rejuvenated orchards added more than fifty thousand bushels to the apple crop.

"In several cases," says the Ohio report, "a net profit of $400 per acre has been secured from an abandoned orchard."

The report continues: "It is like reaping where one did not sow, to bring one of these orchards into its own again. An investment in one of these orchards is better than gold mine

stock, for there is no 'luck' about it. If there is any risk about operations of this sort, it is because of lack of business capacity and industry. To take a neglected orchard and bring it back to usefulness does not require much capital except in brain and muscle, but it is an achievement worth while."

An achievement worth while, the renovation of an old orchard, or even the rejuvenation of a single tree, certainly is. I can gauge something of the growing recognition of this fact from the ever-increasing number of letters that come to me from all parts of the world asking my opinion or advice as to the possibility of restoration to usefulness of trees that their owners not long since regarded as worthless.

And I am usually able to assure the questioners with a good deal of confidence that if they go about it in the right way they will not merely restore trees to their former level of productivity, but may make them producers of fruit in such abundance and of such quality as quite to outclass their original record.

We need not here enter into the details as to the exact methods of operation through which such restoration and rejuvenation of old orchard trees may be brought about. Such details can be given to better advantage in the chapters that

deal with individual fruits. But there are a few general principles applicable to the entire class of fruit trees that may be briefly outlined.

First and foremost, perhaps, is the matter of cutting away the surplus growth of half dead twigs and branches that a neglected tree is sure to exhibit. These serve to distract the energies of the tree, if the phrase be permitted, and, even though they may multiply the number of fruit buds, they will greatly minimize the average size of the fruit itself.

Regardless of quality, fruit trees generally cannot bear to advantage unless properly pruned.

The process may best be carried out late in the winter or very early in the spring. It is well, as a matter of course, to make clean, sharp amputations, so that the bark of the limb below the cut is never torn. No general rule can be given as to the amount of pruning for any species, much less for any individual tree. But it may be taken for granted that the amateur will usually err on the side of pruning too little rather than too much.

Where small twigs are cut away by the pruning shears, it is not necessary to treat the cut surface; but larger branches, requiring the use of the saw, should have the cut surface covered with

hot wax or paint to protect the injured tissues from the weather during the period of healing. This should not be done immediately, but should be delayed for a week or more until evaporation has dried the tissues sufficiently to allow some absorption of the protective material used.

In connection with this removal of supplementary branches, which is in effect a sort of house-cleaning operation, it will be well to scrape off the rough bark of trunk and limb wherever it scales in such a way as to afford snug retreats for insects. And blemishes of a more important order, such as knot holes and decayed surfaces where limbs have been cut away or broken off in the past, should be carefully excavated, all unsound tissue removed, and the cavity filled with ordinary Portland cement concrete.

The latter process has been variously characterized as tree carpentry and tree dentistry.

Both terms are more or less suggestive of the work achieved, regardless of names. The operation may result in prolonging indefinitely the life of a valuable tree that would otherwise soon have decayed beyond restoration.

The trunk and branches of the tree having been put in order, thought should be given to its root system. The casual observer is likely to

forget that only about two-thirds of the tree is visible, and that the aerial half is not fundamentally more important than the subterranean moiety. Yet it is obvious that the root system furnishes the all-important source of supply of moisture and mineral matter, lacking which growth could not take place at all, let alone fruit bearing.

Of course we cannot get at the branches of the roots to renovate them as we have renovated the aerial branches, nor would they require the same kind of attention if we could.

There is no danger that a plant will have too many rootlets, for these are the mouths that reach out into the nutrient earth and take up the chemicals in solution that are part of the materials for the building of branch and leaf and flower and fruit alike. But there is danger that the root system may not develop in the best manner, and there is obvious need that the soil into which the roots penetrate should not be depleted of its nourishing properties.

As to the manner of development of the root system, of course it is too late to make radical changes if we are dealing with an old tree. With young trees just starting growth or recently transplanted much may be done, as will be pointed out presently. But with the old tree all

that can be accomplished is to see that the root already in place is being given a fair chance.

Attention to the Commissary Department

To this end the ground about the tree should be cultivated with plow or spade, even at the hazard of destroying a certain number of superficial rootlets. The grass and weeds that have been permitted to spring up in the neglected orchard sap the ground and take the nourishment that the tree imperatively needs. But if the surface soil is turned under this vegetable matter will in itself constitute a fertilizer. Unless the soil is unusually rich this should always be supplemented with artificial fertilizers, of which nitrates, phosphates, and complete mineral fertilizers often appear to have the best effect in rejuvenating an old orchard.

In case the soil is a sandy loam, subject to rapid leaching, it may be desirable to sow a so-called "cover crop" to prevent the too rapid washing away of the plant foods in the rainy season. If a leguminous crop is grown, such as clover, crimson clover, cow peas, or vetch, these crops will in themselves add to the nitrogen of the soil, as their roots have the power of taking this from the air. But it is urged by some east-

ern orchardists that care should be taken to avoid too much nitrogen. The roots of the tree reach down to rich subterranean sources that are likely to be well supplied with nitrogen, because the nitrates are very soluble and are pretty rapidly leached or filtered into the subsoil.

After preliminary treatment it has been found in many States best to sow a crop of clover, often with other perennial grasses, as a permanent crop, which should be cut and all material left on the ground for the protection and support of the orchard. This has been found to be an extremely profitable method both in the old neglected and in the new orchards of New England and in the orchards of the northwestern Pacific coast. A small space about the trunk of the tree should be kept free from grass.

The experts of the Indiana Experiment Station recommend as a fertilizer, for soil of fair natural fertility and where a leguminous nitrogen-gathering cover crop such as suggested may be grown, the additional use of a fertilizer having the following formula: "A thousand to fifteen hundred pounds per acre of a mixture containing one part (100 pounds) each of ground bone, acid phosphate, and muriate of potash. On soils that are somewhat exhausted

125 pounds nitrate of soda may be added in addition.

"In order to get the greatest returns from this fertilizer it should be thoroughly worked into the soil. This can be accomplished very well by applying it to the surface just before plowing. The plowing and working of the ground will get the fertilizer pretty thoroughly incorporated, and the tree will soon show the beneficial effect of its presence. Hoe the ground often and keep it cultivated until midsummer, then sow a cover crop that will protect the ground until it is turned under the following spring."

After these reformatory measures have been carried out, it remains to guard the trees against the attacks of insects with some protective spray.

The particular insect or fungus-destroying mixture required will, of course, depend upon the individual case. The Bordeaux mixture is doubtless used more than any other single spray for fungous diseases and for the codling moth in apples. A lime-salt-sulphur solution is the general mixture for San José scale. In general, it should be recalled that spraying is a preventive measure rather than a cure. Bordeaux mixture, for example, will prevent the appearance of the fungus disease commonly called scab. The attacks of the codling moth may be met in the

same manner; but as there is a second crop of these moths, another spraying may be necessary later in the season.

Battling the Pests

We should add that as to this matter of fighting plant diseases and pests with the spray, as also in the matter of the renovation of neglected orchards, advice must be offered rather at second hand. My own orchards, as a matter of course, have not been neglected. While my orchards are cultivated thoroughly, so that a weed is seldom seen, very little fertilizer is used and rarely any spraying, as the main object is to obtain varieties that are immune to fungus and insect diseases, and which will thrive in ordinary soils and under ordinary systems of cultivation. No pampered pets are offered from my grounds for general culture.

I would urge any orchardist who operates on a large scale to consider the matter of selecting as far as possible varieties of fruit trees that are more or less immune to disease, rather than to depend on the at best somewhat precarious method of warding off the enemies by spraying. Prevention is better than cure with plants no less than with human beings. But of course the renovator of an old orchard, whose task is at the moment

under consideration, must work with the materials supplied him and cannot ignore the fungus and insect pests that attack his trees; although by dint of proper grafting he may hope presently to transform the character of the trees in such a way as to give them partial immunity. The orchardist of the future will have still better ones in these regards.

It takes time to grow a tree, and it is peculiarly fortunate that the fruit grower can secure almost anywhere in the Eastern States an abandoned orchard that may almost immediately be restored to a condition of productivity. But of course the orchardist who wishes to operate on an extensive scale will never be content with the renovation of an old orchard, however lucrative that process may prove, but will wish to produce a new orchard that may lack the defects of the old one.

The ancient tree made over will still retain, in such important matters as height and spread of branches, the evidence that it really belongs to a past generation, however insistently the fruit that its grafted branches bear may seem to belie the evidence.

But the trees of the new orchard may be trained in accordance with modern ideas; and it is not to be denied that ideas as to tree pedagogy

have changed as rapidly in recent years as have the best conceptions of human pedagogy.

Take the very important matter of height of tree as a case in point. Not long ago the orchardist, in developing a young tree, was careful to see that it was trained in the nursery so that its lowest branches were several feet from the ground.

But the well-informed orchardist of to-day heads his tree in such a way that the bearing branches start only eighteen inches or two feet from the ground.

Where formerly high ladders were required to gather the fruit, a modern orchardist, for many years after his trees are in bearing, can stand on the ground and reach the main bulk of the fruit; and even that which falls is not mutilated and bruised as it used to be. Also the trees are much less apt to be broken or blown over by the wind.

And in all this I am not referring to such "freak" trees as, for example, my Pineapple quinces, scarcely waist high yet almost breaking under the weight of mammoth fruits, but of the commercial orchard, and have in mind in particular the apple tree, because it is with regard to this tree that the most conspicuous transformation has been effected. Plum trees and peach

trees were never very large, but it used to be taken for granted that the apple tree should be of gigantic proportions; so that the half dwarf trees on which the best apples of to-day are grown might seem to the casual observer to belong to a different family of plants from their progenitors.

As to other desirable qualities, much depends upon the location of the orchard and the market that the orchardist has in view.

It goes without saying that the varieties to be selected must be of a character adapted to the climate and soil of the chosen region. As to this, the restrictions imposed by nature are more or less familiar to every fruit grower. In general, you may judge to a certain extent from observation of what is already grown in your neighborhood as to what kinds of trees will thrive there. The chief restrictions are those imposed by conditions of temperature, and of course temperature is influenced not merely by the latitude but by distance above the sea level and the neighborhood of large bodies of water.

The presence of moisture in the air has a protecting influence, chiefly in that it prevents radiation of heat at night. Every orchardist knows that the danger from frost increases in proportion as the night is clear. The now familiar

method of fighting frost by burning brush or oil supplies direct heat, but also supplements this by filling the air with smoke, which retards the radiation of heat.

It is familiarly known that seaboard regions have much milder winters than inland regions of the same latitude.

Again, inland regions of low altitude, such as the Mississippi Valley, may be adapted to the growth of a fruit that would inevitably winter-kill if grown on the high plateaus of Wyoming. In general, it may be said that no region at higher altitude than about six thousand feet is adapted for general fruit growing.

In putting out catalogs of new fruit it is often desirable to state the minimum temperature that a new production will stand. As to average annual temperature, it may be convenient to recall that there is likely to be a mean annual difference of three degrees for each hundred miles of latitude. Thus, for example, the mean temperature at the northern line of Iowa will be found to be about three degrees lower than the mean temperature at the southern line; and this difference might, in case of a given fruit, make it folly to plant in northern Iowa a fruit that might live in the southern part of the State.

As already pointed out, however, one of the main objects of the plant developer to-day is to produce hardy varieties, and doubtless it will be possible in the future to grow most varieties of orchard fruits in regions that are now regarded as lying wholly beyond the northern limits of their possible culture.

Studying the Market

Of course the proximity of the market is an item of chief importance. Yet it may be said that nearness to market is by no means an absolute essential. For of course it is well known that California fruits are now chiefly grown for shipment to the Eastern States. So nearness to a railroad is even more important, as hauling fruit for any great distance before it is packed for eastern shipment is a great detriment to its shipping and keeping qualities.

Except in a few cases, like that of the prune, it is always necessary for the California plant developer to consider the shipping quality of his fruit. A fruit to be shipped a long distance must be of firm flesh, good color, and a reasonably tough skin. And especially it should be uniform in size and of such shape as to admit of economical packing. Moreover, it should ripen at a sea-

SHIRO PLUMS

One of the first of my plum introductions. This variety is a popular shipping plum, though some of my later productions of larger size, brighter colors, and even better quality are now being planted more extensively.

son when the same kind of fruit is not abundant in the distant market.

So it may happen that a fruit otherwise valuable may lack this essential marketing quality, and hence must be avoided. This is the reason why my Abundance plum, the first of my plum products, is not so popular in California as it is in the Eastern States, as it will not stand long shipment as well as other varieties. To the eastern fruit grower this is not important, as he lives near the market. But from the California standpoint, such plums as I have produced and introduced during the past twenty-five years, all of which are excellent shippers, are generally preferred, and are now sent to every city in the Eastern States each season by the million crates, where they arrive in excellent condition and bring the very highest prices.

The advantages of entering the market at a particular season are illustrated by the Burbank cherry, which ripens so early that it reaches the eastern markets when almost no other fruit is on hand. The fact that these cherries often bring ten times the market price to be secured a few weeks later shows the practical importance of this detail.

Another point that the prospective orchardist should not overlook is the question of the color

of the varieties of fruit he is to select. Color is one of the most important characteristics of the fruit from the market man's standpoint. The purchaser at the fruit stand will very generally pick out the highly colored fruit, often without considering its quality.

The Orchard Site

In dealing with an old orchard the fruit grower must obviously take the trees as he finds them. But in developing a new orchard he should give very careful attention to the exact topographical conditions. The matter of drainage of the soil is generally very important, and also the question of exposure to sunlight and wind.

If your orchard site slopes toward the south, and does not lie in the shade of mountains nor where it is subject to the equalizing influence of a large body of water, the trees are likely to be so stimulated by the nearly perpendicular rays of the sun as sometimes to blossom before the time of the late frosts. Early blossoming might at first thought be considered an advantage; but it is a general rule that trees which blossom early ripen their fruit late, whereas those that blossom late are usually early ripeners. The obvious explanation is that the trees that flower late and

ripen early have had to adapt themselves to short seasons.

The wisdom of their course is emphasized when we see the early blossoms of trees on a southern slope cut off by a late frost, while trees otherwise situated in the neighborhood have not yet come to blooming time.

The danger of entire loss from late frosts may be obviated, however, by the selection of varieties that will mature fruit even after the blossoms have been frozen. I have developed such varieties of fruit trees in a number of instances. There are also varieties that have a long blooming season, and these may be depended upon to put forth new blossoms even if the earlier ones were blasted. But in general it is desirable to select a variety of tree that naturally blooms late enough to avoid these late frosts.

This is especially important in view of what has just been said about frosts waylaying trees on a southern exposure, because precisely such exposure is of value at the other end of the season, to hasten the ripening of the fruit. This is not only important in the case of fruits designed to meet an early city market, but it applies to many varieties that tend to ripen late in the fall and which thus may suffer from the early frosts of autumn.

A CURIOUS FRUIT

This odd-shaped fruit is a crossbred plum. It has a large stone in the upper portion, with a hollow recess extending into the lower portion of the fruit. It is one of many interesting abnormalities observed in connection with the plum experiments.

It should be recalled that the warm southern exposure also tends to take the moisture from the soil early in the season, so varieties planted in such a location should be able to resist drought.

Trees planted on a hillside will generally have natural drainage. Otherwise it may be necessary to drain the soil with tile or with open ditches or else to select varieties of fruit that are known to thrive in a moist, cool soil. Such varieties must necessarily have an unusually large leaf surface and shallow root system. For this reason they should not be placed where they are subject to heavy winds.

What may be called air drainage is sometimes quite as important as water drainage. Cold air flows down the hillsides and settles in the valleys. So the bottom of the valley is often a poor place to plant fruit; except, indeed, in certain canyons or gulches where there is a steady current of air in motion throughout the night. In general, the orchard site should be on a hilltop or hillside, or at least at an elevation above the lowest land surface in the neighborhood, unless the valleys are either naturally or artificially well drained. This applies more generally to eastern conditions.

Without attempting further details in this place, enough has been said to show that there are almost numberless points to be considered by

the up-to-date fruit grower in the development of a new orchard. What has been said will supply clues that the thoughtful orchardist may readily follow. As to the specific fruits, further details, with particular reference to the practical aspects of the subject, will be given in succeeding chapters.

"In several cases," says the Ohio report, "a net profit of $400 per acre has been secured from an abandoned orchard."

INCREASING THE PRODUCTIVENESS OF THE CHERRY

More and Better Cherries

WHEN I chance to see mention in the newspaper headings of the doings of New York's celebrated Four Hundred I am sometimes reminded of the Four Hundred of Sebastopol.

The particular Sebastopol that I have in mind is the place where my fruit farm is located, about seven miles from Santa Rosa. By the Four Hundred of Sebastopol I mean a very aristocratic colony, comprising four hundred families of pedigreed cherries, that are colonized on a single big tree in the cherry orchard.

I could speak only from vaguest hearsay as to the lineage of New York's aristocratic coterie, but may claim to discuss the pedigrees of the Four Hundred of the Gold Ridge farm at Sebastopol with final authority, and can vouch for

the blueness of blood, so to speak, of every one of them.

That there are four hundred families in my patrician cherry colony is a matter of accident, quite uninfluenced by any thought of imitation. It chances that year by year the process of elimination about balances the process of addition to the family, and the census of the colony is not greatly altered.

Reference has been made in various earlier chapters to the origin and development of the patrician cherries. They are closely related as to their remote ancestry, as I suppose is the case with the members of every other aristocracy. Yet, as we have seen, the ancestral traits are variously blended in the different families, and there is notable diversity among them as to individual traits. Some of them bear fruit that is vividly red in color, others fruit that is pallid, or purple, or black; and there are corresponding divergences as to flavor, freedom of stone, sugar content, and all the rest of the complex characteristics of a well-bred cherry.

Of course these qualities are variously recombined in the progeny of each new generation. So I can never tell what surprise is in store for me when seedlings are raised from the fruit.

And there are always new additions to the colony that will only come into bearing next season or the season after and reveal what they hold in store.

Thus it chanced that in the season of 1908 I found among the cherries one that bore quite the largest fruit I have ever seen; fruit, moreover, of the most inviting color and having qualities of flesh to match. Cions and trees of this new cherry were sent out and will in due course colonize many an orchard with a new variety of fruit that is sure to find great favor. This cherry was named the Giant and honors its name by producing each season an abundant crop of cherries which measure three inches around.

But if I thus from time to time have pleasant surprises, I am also too often surprised to find among my patrician cherries offspring that seem wholly unworthy. But of course one hears of black sheep among the scions of even the noblest families, so it is not surprising that the blueblood cherries of Sebastopol offer no exception.

And as the black member of any human family is always held up as a warning example, I have thought that I might in the same way make the black sheep of my cherry colony serve a useful purpose by explaining somewhat in detail the reason for their appearance.

In so doing I shall be able, perhaps, to make a somewhat clearer exposition than has hitherto been attempted of certain aspects of heredity that are peculiarly important from the standpoint of the practical plant developer.

Upper Case Qualities

We have learned something in earlier chapters about unit characters and the way in which they are blended or mosaiced together to make up the personality of any individual plant.

It will be recalled that where the two parents of a given individual have opposing qualities as regards a given characteristic—where one, let us say, is black and the other white—it is quite the rule for one quality to dominate the other in such a way that the offspring precisely resembles, as regards that quality, the dominant parent—in this case the black one—and resembles the other parent seemingly not at all. And we have learned also that the latent or recessive character that is thus subordinated—in this case whiteness—will reappear in a certain proportion of the offspring of the succeeding generation.

Now, it has been found convenient by recent experimenters to adopt a graphic method that will make the printed accounts of their experiments more readily comprehensible. The ex-

pedient in question is the simple one of using a capital letter to designate the dominant factor of any pair of unit characters, and a corresponding lower case or small letter to designate the recessive factor.

Letting *"D,"* for example, stand for the dominant trait of blackness in the illustration just given, and *"d"* for the recessive trait of whiteness, we may concisely state the facts of inheritance as just noted in the following formula:

Parent *"D"* being mated with parent *"d,"* the offspring, whether few or many, bear in each individual case in their germ plasm the factors *"D"* and *"d"* in combination. But if two of these offspring are interbred, there will be a splitting up of the factors and recombination in such wise that in any average group of four of their progeny the result will be this: One member that is pure dominant (*DD*), two members that are mixed dominants (*Dd*), and one member that is pure recessive (*dd*). The *DD* individual is "homozygous" for dominant factors and will breed true to blackness. The *dd* individual is homozygous for the recessive factors and will breed true to whiteness. The two *Dd* individuals are heterozygous for the color factors, and whereas they are individually black their offspring will repeat the formula 1 *DD* + 2*Dd* + 1*dd;* they will repro-

NAMELESS SEEDLINGS

These seedlings must be tested for many years to obtain a clear perception of their value, and especially to learn their failings in any particular. The ones chosen for introduction must have a combination of most remarkably good qualities.

duce, in other words, the conditions of the second filial generation itself as just analyzed.

Let me restate all this, using only the letters, to show the convenience of the formula and at the same time fix it in memory: D mated with d in the first generation gives us $Dd + Dd + Dd$, etc., in the second generation. Dd mated with Dd gives us in the third generation $1DD + 2Dd + 1dd$.

If this is not absolutely clear, you will do well to reread the above paragraphs, and it is quite worth your while to consider the matter somewhat attentively.

If you have only theoretical interest in plant breeding, you should be concerned in the matter no less personally, because the same laws of heredity that are about to be illustrated apply with full force to all life, including human offspring.

If, on the other hand, you *have* thought of undertaking some experiments in plant developing, which I hope is the case, it is doubly important you should get the full significance of these simple formulæ. Like other formulæ, they are devised solely for convenience in promulgating ideas. As used in the following illustration, they will make it possible to present vividly the case of our black-sheep cherry, and through this to clar-

ify a large number of obscure cases that must prove very puzzling to the novitiate in plant development.

Explaining the Black Sheep

Let us now state our way, as it were, with the aid of the upper-case and lower-case letters, along the line of a series of plant experiments through which a certain patrician cherry was developed. To avoid complications and to escape getting into a tangle of ideas and a maze of letters, let us consider only a single quality in detail, keeping in the background of our minds the idea that the actual experimenter is at all times considering almost innumerable other qualities as well.

The one quality that we will consider at the moment is, let us say, the matter of size. We wish, for some special purpose, to develop a cherry that shall be a giant among cherries, yet which of course shall combine size with quality.

Now we have at hand a cherry that bears very large fruit of poor quality. We have also at hand a tree that bears small fruit of delicious quality. Our first step will be to transfer pollen from the stamens of one of these to the pistils of the other. We carefully mark the branches bearing the hybridized flowers; and subsequently we

gather the fruit and save the seed and in due course plant it and nurture the seedlings by methods hitherto fully explained.

So when a year and a half has passed from the inauguration of our experiment we have a row of hybrid seedlings ready for grafting.

The one thought that is uppermost in our mind, for purposes of the present exposition, is that of securing a plant that will bear fruit of large size. Now we have learned that there are certain correlations of parts that will enable the plant experimenter to predict, from the appearance of the seedling, a good many things about the quality of the fruit it will subsequently bear. Utilizing this knowledge, we pass along the row of seedlings and select from among the thousand or five thousand individuals the ten or twelve that seem to us to give greatest promise. Nor at this particular stage of the development is the selection very difficult, for the first generation hybrids usually show no very great tendency to variation. That tendency is revealed in subsequent generations, as we have seen.

In fact, as a moment's reflection will tell us, the seedlings before us are really all of one quality as regards the particular characteristic of their innate tendency to bear large or small fruit. One of their parents bore large fruit; the other

bore small fruit. If, then, we assume that here, as in many other cases of plant breeding, the quality of largeness is dominant to the quality of smallness, it may be expected that all the hybrids of the first generation will tend to bear large fruit.

If, introducing our convenient system of symbols, we designate the dominant quality of bigness with the letter *B*, and the recessive quality of smallness with *b*, we may designate the members of the hybrid generation as all being mixed dominants, each bearing the factors *Bb*. This means that the factor *B* dominates the factor *b*, and that the individuals in question will all bear large fruit.

So we may expect (on this assumption), having grafted our selected seedlings, that each of them will show, two or three years hence, fruit of large size, but unfortunately a thousand previous matings will always vitiate this desirable result.

But of course the other qualities of this fruit will not be all that we could desire, so it will be necessary to continue the experiment.

Suppose we do this by cross-pollenizing different members of the same group. We shall thus mate *Bb* with *Bb*. And the result of this mating, as we know, will be to produce, in each group of

four, one *BB* individual, two *Bb* individuals, and one *bb* individual. Being interpreted in terms of our actual row of seedlings, as they stand in our orchard in this, the fourth or fifth year of our experiment, this means that in every lot of four thousand seedlings one thousand are pure dominants as regards large fruit, two thousand are mixed dominants, and one thousand are pure recessives, if we do not take into consideration the fact of past mixed hereditary tendencies.

But now comes a very tangible and very practical complication. As regards their external traits, and as regards the fruit that they will individually bear, the one thousand pure dominants (*BB*) and the two thousand mixed dominants (*Bb*) are identical. There is nothing in their exterior appearance, and there will be nothing in the appearance of their fruit, to indicate which of them contain only the factors of dominance (*BB*), and which contain the recessive factor combined with the other (*Bb*). Yet for the purpose of future experimentation, in which we shall be obliged to call on succeeding generations, theoretically it makes a vast difference which individuals are selected.

We are well aware of this as we walk along the row of our seedlings, but we are also aware that there is no method by which we can fathom

the secrets of our seedlings, to determine which are *BB* and which are *Bb* stock—save only the method of future breeding.

In spite of our best endeavors it may very well happen that the ten or twelve seedlings that we now select, to be grafted for the continuance of our experiment, include not a single pure dominant (*BB*), but are made up exclusively of mixed dominants (*Bb*). We have seen that the latter are twice as numerous as the others, and that the two theoretically look just alike; therefore the chances are two to one that they will be chosen in the majority, and it will not be strange if they are inadvertently chosen to the exclusion of the others.

Yet this choice will insure that the factor of smallness which we are striving to eliminate was carefully preserved in the germ plasm of the cions of this second generation that we now graft into membership in the aristocratic cherry colony.

And when, after another interval of two years, these cions come into flower and are mutually cross-pollenized, the seeds they bear, being the offspring of mixed dominants ($Bb \times Bb$), will produce a generation of seedlings precisely repeating, as regards the quality under consideration, the formula of their parent generation. In

a given lot of four thousand, let us say, one thousand will be *BB*, two thousand will be *Bb*, and one thousand will be *bb*.

And precisely the same difficulty in selection confronts the experimenter that confronted him before.

If he could only *know* which are the pure dominants and which the mixed one, all would be well.

But not only is it impossible for him to know this, but he may not be able even to determine with certainty, from examination of the foliage of the seedlings, which ones belong to the group of three thousand that bear the dominant factor (either *BB* or *Bb*), and which to the group of one thousand that bear only recessive factors (*bb*).

It must be borne in mind that the experimenter is really considering a large number of qualities, and it must be understood also that there may not be any clearly established point of correlation between the foliage or stem or buds of the seedling and the qualities of its future fruit as regards the matter of size; though by practice one can almost certainly select those which will bear the fruit desired by the foliage, growth, and buds; for large, thick leaves and large short-jointed wood and prominent buds are an almost certain

indication of large fine fruit. This is the practical part of the work—not the theoretical.

So it may quite conceivably happen that the experimenter, using his best endeavors to make right selection, picks out for preservation, among the ten or twelve chosen out of the thousands, individuals that, though they have only large-fruited ancestors in the two generations back of them, yet themselves are pure recessives (*bb*) as regards that quality, bearing no factor of large fruit whatever.

And in that event the experimenter will be confronted, after another two-year or three-year interval of waiting, with an array of fruit, borne on the branches of his long-nurtured and carefully selected cions, not a single specimen of which is other than insignificant in size.

Other good qualities the fruit may have. But in the essential quality that we are keeping under consideration it is utterly lacking. In the matter of size it reverts to the recessive member of its great-grandparental ancestry. And so its tell-tale progeny, hanging there among the luscious fruit of surrounding branches (of other lineage), are like the black sheep in a patrician family.

Not an enheartening experiment, thus far, for the would-be developer of a colossal cherry.

Yet the case is not really quite so bad as it seems. There is an old familiar saying that "blood will tell," and our new formula, if properly applied, gives full support to the saying.

Making application of it, we may say that the *dwarf* cherry which we may have developed as the result of about nine or ten years' efforts at the production of a *giant*, is after all a thing of quality, even though it lacks one of the qualities that we are seeking. It is a shrub as to size, but it is none the less a thoroughbred as regards a number of other qualities. In the matter of color, let us say, it is a vivid red; it is sweet and appetizing; it is resistant to disease; it will bear shipping and so on.

Not so Bad as It Seems

Indeed, it is not unlikely that, as regards all desirable characteristics but one, our cherries are of such quality that, even in the patrician ranks in which they find themselves, they must be admitted to be "upper crust," to use a phrase that is said sometimes to pass current in human patrician circles. Or upon reverting to our formulæ, and therefore to the terminology of the printer, we may say that they are "upper case" as regards all qualities other than size.

As to bigness, to be sure, they are pure recessives and must be labeled *bb;* but as to juiciness

SOME CURIOUS SHORT-STEMMED HYBRIDS

These black cherries, it will be observed, have the peculiarity of growing on exceedingly short stems. Such variations as this are observed in many hybrids, and of course they give opportunity for selection, through which permanent varieties are developed. Shortness of stem, however, in the case of the cherry, is a merit that must not be carried too far, lest the cherries crowd each other too much in the bunches.

they are *JJ;* for shipping qualities they are *SS;* for resistance to disease *RR;* for hardiness *HH;* and for productivity *PP*. That is to say, they are pure dominants for each of these qualities.

Their germ plasm requires only an infusion of the dominant factor for bigness and theoretically their progeny will prove that breeding does tell.

There is a tradition that passes current among dog breeders which I do not vouch for but which suggests a condition so comparable to that of our cherry that I cite it by way of illustration. It is said that the greyhound had been bred so exclusively for speed that it developed all the desired speed qualities of a hunting dog, able to overtake any quarry, but lacked the courage to seize the quarry once it had been overhauled. To overcome this defect, so the story goes, some one crossed the greyhound with the bulldog, thus breeding in a strain of courage; and in subsequent generations eliminated all the bulldog traits except courage by selective breeding; and so gave us a race of greyhounds in which the one missing quality had been supplied.

This greyhound legend seems much more plausible to-day, now that attention has been so generally called to the segregation of unit characters, than it formerly seemed. But whatever its truth, the case of the hypothetical greyhound

strongly suggests the case of our black-sheep cherry. This also lacks but a single quality.

Can we not then breed this quality into our cherry and by remedying the one defect attain our ideal?

Solving the Dilemma

Fortunately, yes. This is precisely what we can do, and what the wise plant experimenter will do.

We have but to look about in our cherry colony and we shall find another family, habiting perhaps a neighboring branch, the fruit of which exhibits in imposing measure the quality of size that our protégé of the moment so notably lacks. This big cherry may even be the original dominant parent with which our experiment started. But it is a fruit which, although being everything that could be desired in size, is unfortunately quite lacking in color. In spite of its inviting bigness, it cannot make its way in the market because, even at full maturity, it has the appearance of unripeness.

But it *is* big, and the bigness is the thing we are seeking. So we cross-fertilize the flowers of our little cherry with those of this big one.

The result theoretically is readily foretold. Bigness, as we have seen all along, is dominant, and so the offspring of this union are individually

big. They are mixed dominants (*Bb*), to be sure, but that, as we have seen, is something that concerns their descendants rather than themselves. Individually, they will bear big cherries, and that is all that we demand.

But what as to the color of our new fruit?

Here fortune again favors us. For it is very commonly observed that color of flower or fruit is likely to be dominant over lack of color. So our little red cherry, pure dominant as to color (*CC*) will stamp its influence in this regard on the progeny; the recessive color factor of the other parent (*cc*) being subordinated or made latent. In regard to color, as in regard to size, the progeny will be mixed dominants only (*Cc*).

But here again the fact that they have the recessive factor (*c*) is of no consequence, since, as we have seen, the mixed dominant tangibly presents the quality as markedly as if it were a pure dominant.

So when we have raised seedlings of this union of our little red cherry with the big white one, and when we have waited yet another pair of years, we shall finally be rewarded with the appearance on the cion of fruit that meets our original ideal as to size, is as red as could be desired, and exhibits the other good qualities that entitle it to a permanent place in our patrician colony.

It has taken us about twelve years to accomplish this result. And even now our new fruit must be propagated by grafting and budding, for it cannot be depended upon to breed absolutely true from the seed.

The recessive factors for size and for color, as we have seen, are in its heredity; and these will make themselves manifest in the progeny.

But so long as we confine ourselves to the method of grafting, we may hold the type of the new variety and spread broadcast this big red cherry with its combination of desirable qualities, with full assurance that, given reasonable conditions as to soil and climate, it will reproduce forever the qualities of the patrician fruit, the ancestral history of which we have just traced.

Inviting Opportunities

I have thought that by thus tracing in detail the history of a single experiment, paying heed chiefly to a single quality, but reminding the reader from time to time that other qualities cannot be ignored, we could perhaps gain a clearer notion than would otherwise be possible of the practical steps through which a new form of fruit is developed.

It is through such series of experiments, leading sometimes forward and sometimes backward

in successive generations, that the four hundred families of cherries of my patrician colony have been developed. No two among the four hundred show precisely the same combination of qualities, but all of them show one combination or another of good qualities.

Those that reverted to undesirable ancestral traits have been weeded out.

And this is equivalent to saying that the selected varieties of cherries represent a fixed stock as regards many of their good qualities. We cannot expect that any given one will reproduce its kind precisely from the seed, for reasons that have been fully explained. But we can expect that there will be a goodly proportion among any company of seedlings from this stock that would produce fruit of excellent quality. In a word, then, these perfected varieties of cherries represent stock that is immediately available for the purposes of further experimentation.

What they have accomplished is an augury of still better things that may be expected of their descendants.

And so the practical question arises as to what, specifically, are the qualities that the improved cherry still lacks; and as to what particular experiments in hybridizing should be undertaken to remedy the defects.

IMPROVED HOLLY CHERRY

(*Cerasus ilicifolia*)

There are two quite distinct varieties of this wild California evergreen cherry, also classed as different species. One grows in the mountains of the mainland. This varies in the color and quality of the fruits, while in the Catalina Island species the fruit is always black. Both have much stone compared with flesh, but are sweet and agreeable. My own work during the past twenty years in crossing and selection has resulted in some very large, delicious fruiting varieties, the fruit of which is produced in enormous quantities. The trees are highly ornamental.

The first and perhaps the most important defect that suggests itself is that the newly developed cherries, particularly the sweet ones, lack something of hardiness. They grow to perfection in California, but as yet they are little grown in the eastern United States, and not at all in regions north of Ohio and Missouri. Yet the race of cherries, taken as a whole, constitutes a very hardy stock. The wild cherries of the eastern United States grow far to the north and are able to withstand the winters even in regions where the mercury sometimes freezes.

It should be possible, and doubtless it will prove possible, to combine the best existing varieties of cherry with some of the wild cherries, and thus to develop a race of cherries that will retain the present qualities and introduce additional qualities of hardiness fitting them for growth anywhere in the United States; in fact this is a work in which I am now engaged.

There is a small red cherry, commonly called the bird cherry (*Prunus pennsylvanica*), the fruit of which is sour and astringent, but which is not without qualities of virility and hardiness that might make it a valuable hybridizing agent.

This is perhaps the hardiest of all cherries. I have seen it growing wild nearly as far north as

Hudson's Bay, in regions where it is not uncommon for the mercury to fall sixty degrees below zero.

The California holly-leaf cherry (*Cerasus ilicifolia*) and the Catalina cherry are species that may be available for the development of other desirable varieties—for it is not in hardiness alone that the best varieties sometimes are found wanting; though the species just named are so far separated biologically and physiologically that it will no doubt be impossible to combine them with our more common cherries.

Many cultivated cherries, for example, are unable to withstand the warm spring rains without serious loss from cracking of the fruit. Sometimes almost an entire crop will thus be ruined. Again many cherries are susceptible to blight. A bulletin issued by the State Commission of Horticulture of California lists more than twenty insects—leaf hoppers, scales, mites, caterpillars, and borers—that prey more or less upon root or bark or leaf of the cherry tree, or that attack its fruit.

Then there are inherent maladies, such as the tendency to overflow and condensation of sap, forming an injurious gum that may induce decay of bark and wood (called gummosis), to which the cherry is peculiarly liable.

Hybridizing with some wild species, intelligently and systematically carried out, might produce varieties of cherry that would show exceptional resistance to insect pests as well as inherent vitality that makes for vigor in the tree.

It has long been my belief that a solution of the problem of protecting our fruit trees from both insect and fungus pests must eventually be found in the development of the qualities that make for immunity of the trees themselves, rather than in the resort to such expedients as spraying and "gasing." In this regard the plant experimenter may well take a leaf from the notebook of the physician, who has learned that immunity to disease often depends more upon the condition of the patient than upon the presence or absence of disease germs.

It is possible, furthermore, that the cherry may be hybridized even more widely, and that a fruit differing markedly from any cherry hitherto produced may thus be developed. An inkling of the possibilities in this direction is given by some experiments made recently by Professor N. E. Hansen, of the South Dakota Experiment Station, who has cultivated a variety of wild fruit, called the Sand Cherry, *Prunus besseyi,* which is a dwarfed, compact grower, of heavy form and good foliage, and which had previously been put

THE HOLLY CHERRY

One of my improved hybrid varieties at the center and left; original at the right. All of these Holly cherries (Cerasus ilicifolia) ripen late in the summer.

upon the market as the Improved Dwarf Rocky Mountain Cherry. This native tree has a fruit nearly as large as the Richmond cherry and sometimes of fairly good flavor. The *Prunus besseyi* has always been considered a cherry by horticultural and botanical writers. My experiments, however, seem quite clearly to demonstrate that it is more truly a plum.

I have had the tree under cultivation for more than twenty years. The fruits of the original plant were black and bitter, almost as astringent as a persimmon. By combining this plant with various other American and Japanese plums, I have produced abundant seedlings, and in 1904 had developed one especially promising variety. The fruit of this hybrid seedling ripens in California about August 10, and is extremely large for this type. It is globular, and about one inch and a quarter in diameter. The color is pure, deep crimson, with a semitransparent amber flesh, firm, juicy, and of rich, sweet flavor, resembling that of the American plum. The tree is intensely productive, even sometimes breaking with its own weight of fruit.

It has been suggested that this tree gives great promise as an aid in the production of a hardy type of fruit that will withstand the rigorous climate and conditions of the cold northern plains

of Nebraska, Minnesota, and the Dakotas. What has just been said suggests that the fruit is not truly a cherry, yet the botanists seem to feel that it occupies an intermediate station, and is more closely related to the cherry than any other fruit.

Such being the case, it should be possible to hybridize this dwarf hardy species with the cherry. The tree has the further valuable property of being able to grow on dry, barren sands. A hybrid cherry having this characteristic from one of its ancestors might be expected to constitute a fruit that would grow in regions too arid for the existing cherry as well as in regions that are too cold. And this is but one of the several lines of possible development that invite the plant experimenter who will give attention to this type of cherry.

To suggest one other line of improvement, it is sufficient to call attention to the familiar fact that the cherry has a very brief season. The Burbank cherry fruits a week or two earlier than most others, as we have learned in another chapter. But even so, the total period during which cherries of different varieties are in fruit is very limited. One hears reports of an exceptional cherry tree that fruits a second time in the autumn. By the usual process of raising numerous seedlings, or by crossing and selection, a variety

having this fall-bearing habit might be produced. The value of such a variety is obvious—though the early ripening of the cherry is at present what gives it greatest value—and it is well worth the while of the amateur to attempt experiments in this direction.

The fact that cherry trees of one kind or another grow throughout the United States makes it possible for almost anyone to experiment with this fruit. And the opportunities for improvement are especially inviting.

This chapter has in some cases been more theoretical than practical, yet it is well to know something of both. Read it and then forget most of it if you wish to succeed in producing valuable cherries.

THE RESPONSIVENESS OF THE PEAR

What Has Been Done Is but the Beginning

A CORRESPONDENT who is seemingly prone to personify inanimate objects writes to ask which tree among our cultivated ones I regard as the most "human."

And then, without awaiting reply, my correspondent supplies the answer:

"The pear, of course," he says with full assurance.

But when he goes on to state the reasons for this decision, I am not quite sure that his argument carries conviction.

Perhaps the most striking bit of analogy that he offers is the fact that a pear tree sometimes fails to reach maturity until it is from fifteen to twenty years old, coupled with the cognate fact that the tree may continue to thrive for three score years and ten or even longer.

He cites a good many other analogies, or supposed analogies, to be sure—the fact that the

pear overrides adversity, as it were, bearing abundantly in bad soils and when totally neglected; the fact that it grows by roadsides and in dooryards showing a domestic habit and as it were a friendly spirit toward man; and finally, the fact that it responds to attention and proves as receptive and responsive to really good treatment as it is resistant to bad.

But I am by no means sure that as to most of these traits, and for that matter in regard to any others that might be mentioned, the apple tree is not to be given a place quite on a par with that which the pear can claim. There is no occasion to discuss the matter, however, for at best such comparisons have no great significance.

Let it suffice that the pear and the apple, close cousins as they are, may very well be considered the two orchard trees that are friendliest to man, in the broad use of the word.

They have been his associates probably almost from the earliest times when he learned that plants would respond to cultivation.

They have gone with him on his chief migrations throughout the temperate zone and even well into subarctic regions.

They have proved themselves adaptable to all soils and nearly all climates; and they jointly produce a variety of pulpy fruits that stand in a

class by themselves and are quite without competitors—or were until the quince came under the hand of the plant developer in very recent times.

Early Migrations

Which of the twain, pear or apple, was first adopted, no one can say, but it is certain that both were friends of man even in prehistoric times.

There is evidence from the ruins of remote civilization of the lake dwellers of Switzerland that the pear was known even in that day. Of course it was familiar to the Greeks and Romans from the earliest recorded periods of history.

Long before that it had come out of its central Asian home—if, as is almost certain, that was its original habitat—and had become thoroughly domesticated about the Mediterranean. Other branches of the same race had migrated eastward until they found a home in China and Japan.

And in these widely separated regions, at the extremes of the largest continent, the two descendants of the primitive stock developed, each in its own way, in response to soil, climate, and the diverse temperaments of the peoples, until the pear of Europe was in many ways a different fruit from the pear of the Far East.

But there was one migration made by prehistoric man in which the pear, apparently, did not accompany him. This was the final stage of the eastward journey of our remote ancestor which carried them across a land bridge, now no longer in existence, between northeastern Asia and the present Alaska, and thus brought them to America.

It seems a fair presumption that when prehistoric man made this final migration he brought the apple with him.

At all events, with or without man's aid, the apple made its way across the bridge that joined the continents.

Probably the fact that the seeds of the pear will not germinate when once dried may explain the failure of that tree to come with the forerunners of the Indian to the new continent.

The seeds of all orchard fruits germinate far better if they have not been too thoroughly dried But the seed of the pear is peculiarly susceptible to destruction through drying; and if the ancestral pear had the same quality, which we need not doubt, this fact may in itself have been instrumental in restricting the spread of a tree which, when introduced in America in modern times, proved thoroughly adapted to our soil and climate.

We must not press this point too far, however, for the plum seed also dies if dried; yet the plum came to America in prehistoric times along with the apple. And, for that matter, we shall see elsewhere that there is another possible interpretation of the story of the prehistoric migrations of the trees.

Be all that as it may, the pear retains to this day evidence of the inherent need, in the interest of its race, that the seeds borne at the heart of its fruit shall be preserved in a moist condition.

The skin of the pear, except in the most recently modified varieties, is firm and thick. It is of a green or mottled yellow color calculated to protect it from the observant eyes of birds and animals rather than to attract them. It has been assumed that the eatable pulp that surrounds the seed was designed by nature—that is to say, developed through natural selection—for the purpose of attracting animals and birds, that these creatures may aid in disseminating the seed.

But the case of the pear, in common with that of the wild crab apple, suggests that the chief purpose of the fruit pulp is to keep the seeds moist until the season for growth arrives. As a further aid to this, and in token of the moisture-loving quality of its seeds, the skin of most wild pears has a granular or even gritty texture.

A PATRICIAN

This seedling pear has qualities of form that entitle it to special consideration. It has also good qualities of flesh, but, as will be seen, it is quite lacking in richness of color, except just about the stem, where there is a splash of red that suggests submerged hereditary color factors that can be brought to the surface by selective breeding.

This unique quality of the fruit may even extend through the whole pulp itself, especially with the more primeval forms, giving the pear a texture different from that of any other fruit.

This unusual habit of depositing grit cells in the fruits, aside from the seed case itself, is no longer of use to the cultivated pear; but the fact that it tends to be retained shows how important a part it once bore in the struggle for existence of the pear's remote ancestors.

But let us put aside theories as to the remote history of the pear and consider the fruit in its modern relations.

The significant thing to bear in mind is that in our day the pear is represented by two races, obviously related, yet quite as obviously long separated, one of them finding its home in Europe and (since the Discovery) in America and the other being indigenous to western Asia, the two having thus migrated in opposite directions, circling the earth, and finally meeting on the Pacific Coast of America.

And the fact that these two races of pears have thus diverged, yet still retain the capacity to hybridize, is an all-important one from the standpoint of the fruit developer.

This fact is, indeed, the basis of the newest progress in the development of the pear, and it

gives promise of still more important developments probably to take place in the near future.

It is only fair to recall, however, that the new beginnings in the development of the pear took place in western Europe independently of an oriental alliance.

New Beginnings in Europe

The pears of to-day, as known in the eastern United States, and for that matter most of the finest Californian varieties, are the bearers of an impulse to development that was given by a French horticulturist, Jean Baptiste Van Mons, and Andrew Knight of England about a century ago. Van Mons acted on a theory, now abandoned, that young plants produce the best progeny. But this led him "to sow, to resow, to sow again, to sow perpetually." And he selected his seeds with such care as to develop many improved varieties. In particular, he taught some pears to bear fruit in three years from the seed.

Van Mons produced by selection about four hundred new varieties of pears, among others a dwarf variety that was a prolific bearer.

Meantime, however, the pear was making its way in America, and one of the most famous varieties, the Seckel, originated in the early part

of the nineteenth century in a fence corner on the farm of a man whose name it bears near Philadelphia.

At the time of its origin the Seckel was pronounced by the conservative London Horticultural Society to be superior to any European variety of fall pear then known.

Rather curiously it chanced that the next very notable step in the progress of the pear also took place on a farm near Philadelphia. The owner of the farm was Mr. Peter Kieffer. The thing for which he was responsible was the introduction of a pear bearing his name, which originated through the chance hybridization of a pear of European strain with the Chinese sand pear, which had been introduced as an ornamental garden tree not long after relations were established between America and the Far East.

The oriental pear which thus at last came to mingle its racial strains with those of this remote relative, after the two had traveled around the world in opposite directions, was a graceful tree having large and attractive flowers and bearing fruit of a pleasing fragrance but of such consistency as to be almost uneatable except when cooked. In spite of the defects of its fruit, however, the oriental pears have certain qualities of hardiness and resistance to disease that make

them valuable mates for their European cousins. So the Kieffer pear soon gained popularity.

So also did a number of other hybrid pears of similar origin, including the Le Conte, the Garber, and the Smith. These hybrids soon became standard pears in the Gulf States, where the European pears do not thrive.

Mammoth Pears in California

The hybrid pears did not gain popularity in California, because the climate and soil of this State seemed to be peculiarly adapted to the European pears, notably the Bartlett.

By crossbreeding and selection these have been so developed, without hybridization with the oriental species, as to assume almost colossal proportions, and while differing widely in flavor from the original stock, to retain enough characteristics of the original to constitute a most valuable market fruit.

The California pears, indeed, have quite outdone themselves. They have been described as "grand in size, delicate in color and aroma, and of unsurpassed richness." A specimen has been reported that was "nine inches high, sixteen inches around the base, and five pounds in weight."

Pears of allied varieties show scarcely less notable tendency to grow to unprecedented size;

for example, five Vicar of Winkfields are reported as weighing four pounds, eight ounces; nine Easter Beurre as weighing 24½ pounds, the heaviest single specimen weighing 2¾ pounds.

In the mere matter of size, then, there remains little to be desired; but there are other qualities as to which not so much can be said. In particular the pear is often susceptible to disease, and in general the extreme development of productivity has been more or less associated with a tendency to lose vigor, rapidity of growth, and general vitality.

For this and sundry other reasons it seemed to me that it might be desirable to make further experiments in the blending of the oriental and occidental heredities. So as early as 1884 I made importations of the seeds of the Japanese pear. In a shipment containing loquats, plums, chestnuts, persimmons, gooseberries, blackberries, peaches, and raspberries, I received also twenty pounds of pear seeds.

The seedlings were grown, but at first little use was made of them except as grafting stocks.

The valuable developments that ultimately came from the introduction of the oriental heredities were not secured at the outset.

Traits of the Oriental Pear

About 1890 I imported from Japan large quantities of the seeds of the Chinese sand pear. The seedlings proved extremely variable. Some of them grew six or seven feet the first year, while others from the same lot of seed, under exactly the same conditions, grew only a few inches; and a corresponding rate of growth characterizes the seedlings as long as they live. But, although the seedlings themselves proved so variable, their fruit was singularly uniform in size and quality.

As to shape, the fruit of the oriental pear is usually oblate, approaching the globular. This raises a rather curious, if not very important, question as to whether the European pear owes its very characteristic shape to artificial selection. The ordinary pear, as everyone knows, has a form that is so individual and so little duplicated, that no single word of familiar usage describes it. In this regard, as in a good many others, the pear is unique.

One would not commonly think of describing anything as "apple-shaped," or "peach-shaped," or "plum-shaped," but "pear-shaped" is a cognomen that is at once convenient and definitive.

So the fact that the oriental pear has not assumed this shape has a certain interest and suggestiveness.

The hybridizing experiments that were begun as soon as I was in possession of the oriental seedlings called for more patience, perhaps, than almost any other tests that the fruit experimenter can make, for the very obvious reason that the pear is the slowest to mature of all the fruits grown in temperate climates. It often requires from ten to twenty years for seedlings of the pear to come to their first fruiting. The matter may be forced a little by grafting the pear cions on quince stock, but while this makes them fruit earlier, it also tends to dwarf them, and I do not recommend this as a general practice, though highly desirable for special purposes.

Whoever has not patience to wait had best not undertake experiments with the pear.

With a tree of such slow development, it is peculiarly desirable to make no mistakes in selecting seedlings for preservation. Judgment as to the future tree must be based, as with other fruit, largely on its growth, and the appearance of the foliage. Pear seedlings that have an abundance of large leathery leaves, and strong, thick, short-jointed wood, and thick, fat buds,

are those to be selected. But this is not by any means as sure an indication of superior fruit in the pear as in most of our cultivated fruit, for the reason that Van Mons and other workers in this line have mostly sought early bearing and fine quality of fruit, neglecting the foliage and growth of the tree almost wholly.

The Effect of New Blood

I grew great quantities of pear seedlings from seed imported in 1884 from Japan. The selected seedlings of this original stock have enormous, glossy leaves, some of which for weeks after the first frost show varied and brilliant colors almost like the autumn foliage of the oaks and maples of the Northeast. Many of the best of these were distributed for planting as ornamental trees.

Very early in the experiments I found among many seedlings of a cross between the Bartlett and the hybrid Le Conte one that seemed to have exceptional qualities. This proved to be astonishingly productive of fruit of the largest size and fine quality, and the tree had extraordinary vigor of growth and was apparently immune to the blight.

But only one was selected as showing good promise as a fruit bearer. Through further hy-

bridization and selection, during a period of nearly a quarter of a century, the hybrid progeny of this Japanese pear developed a variety that was introduced in 1911 as the "Test."

Year after year it had produced two or three times as much as any other pear that I had ever grown. The fruit averages rather larger than that of the Bartlett, and it appears about four weeks later. The flesh is similar to that of the Le Conte, but superior to it in quality, although hardly comparable to that of the Bartlett except when cooked.

Although I have raised and fruited numberless seedlings from a great variety of crosses, and have noted many variations, only two have thus far been thought worthy of introduction. Several hundred three-year-old seedlings of this new pear, grafted on quince stocks, give great promise by their vigorous, compact growth, heavy foliage and full, round buds.

Among those that have fruited are some mammoth pears of exquisite quality when cooked; and a few are good when fresh.

There is unusual variation in growth of wood, foliage, season of ripening, form, size, and quality of fruit. Some of the hybrids have a smooth, polished skin with red cheeks; others are russet throughout or various shades of yellow and

DISSIMILAR TWINS

These seedling pears are full sisters, notwithstanding their extreme dissimilarity of appearance. They illustrate the curious segregation of characters—in this case the color of the skin—in organisms of mixed heritage. It is obvious that the pear at the right has qualities of color that the plant developer is sure to seize upon.

orange. The varying qualities of the hybrids are doubtless due to the releasing of latent characters brought about by the commingling of the two widely diverse strains.

It was necessary thus to hybridize and select through successive generations, because the oriental pear brought to the combination very undesirable qualities of fruit as to texture and flavor. Only when these were eliminated from later generations, and the qualities of the Bartlett and its allies substituted, did the hybrid pear become a commercial possibility.

But, along with its undesirable qualities of fruit, the oriental pear brought other qualities that were preeminently desirable. First and foremost it had fundamental vigor of constitution that promised to supply precisely what the European pear most lacked. This was manifested not only in the vigor of its growth, but in its almost entire immunity to the attacks of the disease that has been the scourge of the pear growers of America for more than a century, and which made its appearance in California about ten years ago, known as the pear blight.

The Pear Tree Scourge

To appreciate the importance of this element of resistance to disease, as manifested by the

oriental pear, it must be understood that the blight is a malady of such virulent nature that when it attacks the pear tree it very commonly results in killing it outright. This suggests, obviously, a peculiar susceptibility on the part of the pear. Such susceptibility is manifested, unfortunately, in exceptional measure by the best European varieties, including the Flemish Beauty and the Bartlett. This, presumably, is the penalty of overspecialization in a certain direction, or unbalanced selection.

Until very recently the cause of pear blight was much disputed, but conclusive proof is now furnished that it is a bacterial disease, due to the presence of a germ that has been named *Bacillus amylovorus*.

This germ has close cousinship with the various tribes of bacilli that cause the contagious human maladies. And there is a curious resemblance between the assault of the microbes on the pear tree and the corresponding assaults of certain bacilli, for example the diphtheria bacillus, on the human organism. In one case as in the other, the bacilli, once they find a lodging place, multiply inordinately and give out excretions that are virulently poisonous. Located on the flowers and fruit of the pear, or finding their way to the inner bark or cambium layer of the

tree, they multiply prodigiously and exert a malignant influence that withers blossoms, blights the fruit, and causes the leaves to take on a bronzed red hue that is often premonitory of the death of the tree.

If they find lodgment in the cambium layer of the trunk, they may spread rapidly in every direction until they girdle the tree, shutting off its supply of sap as effectively as if it had been girdled with an axe.

Wherever lodged, the colonies of bacilli may be located by the oozing out of a milky or dirty brown sticky liquid when the spring rains come. This liquid is attractive to insects, and as the feet and bodies of these marauders become covered with the germ-laden fluid, the transfer of the germs to other trees and to flowers and fruit even fairly remote is thus assured. Not merely flies and gnats, but the bee itself may have a share in thus transporting the contagion from one tree to another till it infects every tree in the orchard.

The nectary of the pear, which the bee may inadvertently inoculate, furnishes a most favorable medium for the multiplication of the bacilli. Thence they work their way from the fruit buds to the limbs. Once they gain access, through the links in the tree's armor furnished by the buds,

to the cambium layer of the inner bark, there is nothing to prevent the indefinite extension of their colony.

A tree thus inoculated may soon take on the appearance of a tree scourged by fire. Indeed, the malady is sometimes spoken of as "fire blight."

Antiseptic Surgery in the Orchard

The measures taken by the horticulturist to save his tree when thus attacked are curiously suggestive of the methods of the modern surgeon. Infected limbs must be amputated; local areas of infection in the bark or trunk or large branches must be thoroughly excised, including a goodly portion of healthy wood and bark to make sure of the removal of every microbe. Large wounds are then carefully disinfected with a sponge or bunch of waste soaked in kerosene or in a solution of corrosive sublimate, one part to the thousand.

It is merely antiseptic surgery applied to the tree to combat a microbe closely similar to the ones that are man's most malignant enemies.

But, of course, such measures as these, however necessary, can by no means be regarded as solving the problem of the pear blight. Just as the surgeon of to-day attempts to prevent the

intrusion of the germs, rather than to depend on killing them after they appear, so the orchardist must hope to find a means of preventing the blight instead of being obliged to practice such heroic and wasteful curative measures.

One measure looking to this end that has been suggested is the destruction of old hawthorn and wild crab apple trees and abandoned pear and apple trees in the neighborhood of the orchard, since a single infected tree would prove a source of danger to every tree within a radius of a mile or more.

Such measures are important; but they do not go to the root of the matter.

The real solution must come through *making the tree immune to the attacks of the germ.* This is the keynote of preventive medicine with the human subject to-day, as illustrated by the vaccine treatment, of which the most familiar example is inoculation for the prevention of typhoid fever. It is at least within the possibilities that a not dissimilar inoculation may give the tree immunity by developing its powers of resistance, quite as the human subject is given immunity.

Of course the tree has no arterial system that can be inoculated with hypodermic syringe as the human subject is inoculated. But the life of the

tree is dependent on the circulation of fluids within its tissues none the less. These fluids are taken in by the roots, and they find their way to the uttermost leaf. So it is conceivable that by proper treatment of the soil about the tree, the tissues of the tree itself might be so altered as to become resistant to the attacks of the bacterial enemies.

Immunity Through Treatment and Breeding

Nor is this idea altogether theoretical. Experiments have already been made that look to the checking of the growth of the tree by withholding fertilizers and water, that the development of the tender buds and shoots, which are the usual points of attack of the enemy, may be made to take place slowly and thus to present tissue of a less succulent order.

Such hardening of the wood by withholding water has proved effective in the case of some pear orchards in Colorado, where it appears that the pear does not really need so much water as it ordinarily receives.

But the effort to give the tree immunity must go even deeper. Induced immunity is valuable, but the ideal condition is that of inherent resistance, bred in the tissues.

Physicians tell us that the all-important thing in warding off bacterial infections in the human subject is the inherent vitality and resistance of the patient himself. In the last analysis, this is the prime essential. A thoroughly rugged organism may be immune to almost every type of bacterial disease. We are told that almost no one escapes infection with the germs of tuberculosis. The ones who show no evidence of the disease are simply those whose tissues are so resistant that the attacks of the bacilli are thwarted.

The horticulturist must take a lesson from the experience of the physician, in particular with regard to the malady we are now considering; for, as we have just seen, the analogy between the pear blight and human infections is almost perfect. So the ideal at which the plant experimenter must aim is the development of a tree that will be immune to the attacks of the bacillus, however freely the germ finds access to it.

My new hybrid pears, thanks to their oriental heritage, seem to fulfill this condition. The same thing appears to be true, at least in some measure, of the other hybrids that have the oriental strain. So there is every reason to hope that we shall be able to develop races of pears, having all desirable qualities of fruit for the different markets, that will be free from the pest that

AN IDEAL PEAR

In form, size, color, texture, and flavor this is one of the best of several hundred thousand of my crossbred seedlings of the oriental and American types.

hitherto has made the raising of this fruit a more or less precarious industry.

Ideals and Possibilities

As to the other needs and possibilities of pear development, not much need be said. Reference has elsewhere been made to the desirability of giving the pear a brilliant color; but this can doubtless be accomplished without great difficulty. It has also been noted that as to size of fruit, as well as in the matter of form, there is little to be desired by way of change.

There is, however, one quality that the specialized pears have markedly lacked. They will keep for a time if picked while green, and will ripen off the tree. But if allowed to ripen on the tree they decay very quickly after picking. It is obviously desirable that the pear should be given keeping qualities. But here, as in case of immunity to the blight, the solution is already in sight.

Among the varied fruits of my hybrid seedlings, there are some that produce winter pears that keep quite as well as ordinary winter apples.

These furnish the foundation for future hybridizing and selecting experiments, through which, without question, it will be possible to produce races of pear having all the qualities of

flesh that have hitherto made the fruit popular, and with the added property of keeping over winter.

Other possibilities of pear development lying a little further in the future and therefore somewhat more vaguely outlined, have to do with the hybridization of the pear with the allied fruits of related species. It is well known that the pear shows, in this regard, a strong disinclination for entering into such an alliance. The pear may be grafted on the quince, but it is usually considered impossible to graft it on the apple.

I have successfully carried out such a grafting experiment, however, when I was a boy in Massachusetts, the cion being a Seckel pear. But although this grafted cion bore very superior large, highly colored fruit for two seasons, it then died, probably because of the uncongeniality of the alliance.

This experiment shows that there is not complete antagonism between the two species; and the same thing is further demonstrated by the well-known fact that the apple may be grafted on the pear stock; although here also the alliance is not likely to prove fruitful and satisfactory. But of course grafting is only an incidental adjunct to the work of the plant developer. The impulse to progress must come through hybridiza-

tion and selection. Here, it appears to me, there are great possibilities. I have crossed the pear and the apple; also the pear and the quince. The seedlings from these unions have sometimes seemed thrifty, but were always infertile. They were highly interesting none the less.

One of the most successful crosses was obtained by using the pollen of the Bartlett pear upon the Gravenstein apple.

The seedlings from this cross were divergent in appearance, and variable as to growth. One of the seedlings grew fully as fast as the ordinary apple seedling, but most of them had a sickly, dwarfed appearance, and some died after having made a foot of growth. Three or four of those that lived were grafted on an apple tree. They maintained moderate growth for several years, but were never healthy or vigorous, and never gave any intimation of blooming.

The results of the crosses between the pear and quince were closely similar. From these hybrids also I failed to secure fruit. Some grew with great vigor for years, while others almost refused to grow at all. In general appearance, and especially in foliage, the hybrids bear a closer resemblance to the pear than to the quince. But most of them appeared to be good composites of these widely differing plants.

As there are many varieties both of pears and quinces, each having individual characters and diverse hereditary tendencies, an inviting field is open to the careful and patient experimenter in crossing these distinct yet related species. If the right combination can be effected, the results undoubtedly will be profoundly interesting and valuable. Precisely what these results will be, no one can predict. But that new fruits, making most valuable additions to the dietary, may ultimately be thus developed, there is no reason to doubt.

The pear and its cousin the apple are two orchard trees which have long been companions and friends of man.

FUZZY PEACHES AND SMOOTH-SKINNED NECTARINES

Two Fruits Which Await More Improvement

"MR. BURBANK," said a fruit grower, "you have taken the thorns off the blackberry bush and the spines from the cactus. Now, why can't you take the fuzz off the peach?

"Most of us don't deal much with blackberry briers or with cactuses, spiny or otherwise; but we all eat peaches, and a good many of us would about as willingly bite into one of the old spiny cactus fruits as a fuzzy peach. If you will only take the wool off this otherwise perfect fruit, we will raise a monument to you by popular subscription."

"But nature took the wool off the peach some thousands of years before you and I were born," I replied; "and I have not heard of any monuments being erected in commemoration of the event."

"What in the world do you mean? A fuzzless peach—who ever heard of such a thing?"

"Everyone has; the fruit that you call a nectarine is precisely that—a peach without the fuzz."

"But that does not serve the purpose at all," he insisted. "If the nectarine is a peach that has lost its fuzz, it is also a peach that has lost its flavor. What we want is a fuzzless peach with the true peach flavor remaining."

"Well, I think I shall be able to satisfy you even there before a very great while," I answered; "for I am on the track of experiments that are likely to meet all your requirements in that direction. Even now I have a fruit that is smooth-skinned and yet is unquestionably a peach—not only that, but a peach of excellent flavor. But it is not yet quite good enough to put on the market, and I shall have to carry the experiment a stage or two farther before I am ready to demand that monument."

In another part of the orchard I already had a number of fine varieties of peaches with perfectly smooth skins, some of which are of extra flavor, though none to quite compete with the best peaches now on the market.

My visitor assured me that nothing else that he had seen gave him so much satisfaction or aroused

such pleasurable anticipations as these smooth-skinned peaches.

It is probable that a very large number of persons under the same circumstances would be of the same mind, for the aversion to the fuzz of the peach is by no means an uncommon form of phobia.

It might be of interest to inquire just how this curious antipathy to anything so soft and delicate as the structure of the peach's skin was developed. I know men of perfectly stable nerves who cannot touch a peach without experiencing a disagreeable sensation, and who cannot bite through the fuzzy surface without shuddering. And as there seem to be large numbers who experience more or less the same sensation, it goes without saying that there must be some hereditary basis for this curious and apparently absurd prejudice.

It is perhaps somewhat comparable to the fear of the mouse so common with women, or the instinctive dread of the snake that most of us feel.

Just how the peculiar antipathy was developed, would be a curious matter for speculation. Here however, we are concerned with the fuzz of the peach not in its direct relation to human psychology, but in its bearing on the heredity of the peach itself. To the plant developer this is a matter of interest, because linked with it is the

THE NECTARINE

The fruit here shown, the nectarine, is much less familiar than it deserves to be. It is in reality a form of peach. The botanists question whether it is not specifically identical with the ordinary cultivated peach. We have obtained most remarkable results by crossbreeding the nectarine with the peach and with the almond.

question of the way in which the superfluous skin covering can be eliminated.

We may feel quite sure that unless the woolly coating at some time served an important purpose, it would never have been developed; or, once developed, it would not have been retained.

That is assuming, however, that the peach developed this unusual fruit covering in a state of nature, and without the aid of man's selective influence, which it certainly did.

How the Peach Obtained Its Coat

If it could be shown that the fuzz was developed only after the peach came under cultivation, and in response to man's wishes, the case would be altered. In that event it might readily be that the fuzzy covering, appearing first as an accidental "sport," had been retained because it pleased the fancy of some plant experimenter, or met the taste of some influential market man—say of Athens in the olden days, or of Rome in the time of its power.

But the peach had its fuzzy coat at a time vastly more remote than this. It is almost certain that the coat was developed long before the fruit came under cultivation.

The fair presumption is, probably, that the ancestor of the peach, wandering from one territory

to another, as all plants do, found itself at a certain stage of its career in an environment where the conditions of moisture and wind and sunshine were peculiarly trying, but more likely where some insect or fungoid or bacterial pest menaced its immature fruit. And in such a case it may readily have chanced that a peach that tended to produce a skin of exceptionally resistant texture, one in which the bloom assumed a more than usually powdery or fibrous character, was given protection against the enemies, and thus preserved where fruit with smoother skin was destroyed.

Under these circumstances the incipient fuzz on the peach would serve as material for the operation of natural selection, and a race of peaches bearing fuzzy-skinned fruit would presently supplant the tribe of smooth-skinned peaches.

Something like this, no doubt, we should find to be the history of the evolution of the fuzzy-skinned peach, could we look with some necromantic microscope into the germinal center of the peach seed and translate the marvelous history of endless generations of peaches, back to the beginning, that is therein recorded.

There is no such microscope as this, of course.

But we can, in a sense, perform the same necromantic feat, and lay bare the mysteries of the history of the evolution of the race of peaches, in a quite different manner.

If you have read the earlier chapters of this work, you will know that the method I have in mind is the familiar one of causing the peach, with its weird record of past events, to blend with another tribe of plants having a somewhat different history; in order that the conflict of tendencies thus brought about (as we used to say; or the blending of hereditary factors, to use the popular phrase of the moment) shall bring to the surface and make tangible in the hybrids of a new generation the traits that were submerged and hidden in the individual plant before us.

And when this familiar yet no less wonderful test is applied, we learn, among other things, that the peach, which now holds to its fuzzy coating so tenaciously, at one time had a cheek as smooth as that of any other fruit. For, among the offspring that appear as the result of blending peach strains, there now and again is one that bears smooth fruit.

Moreover, the smooth fruit that thus appears is closely similar to another fruit which, from its general appearance, would be declared by any

THE LEADER PEACH

This is a second generation cross of the white nectarine and the Muir peach. The nectarine was quite acid, but large; the peach was unusually sweet, but small; the combination produced the most desirable result that could be imagined—a fruit of exquisite quality. (*Reduced one-half.*)

competent observer to be a close relative of the peach, namely, the nectarine.

So this bit of evidence from heredity—this freak of atavism—may be taken as furnishing substantial evidence that the ancestor of the nectarine was also the ancestor of the peach. Or, stated otherwise, that the peach is in reality a modified nectarine. It may be added that both are undoubtedly modified from a plum-peach-apricot-almond ancestor.

That the nectarine, rather than the peach, represents the ancestral form is witnessed by the fact that the nectarine is rarely observed—at least in my experience—to produce a fuzzy fruit, however closely it may otherwise simulate the peach. And, of course, this evidence is in keeping with the natural inference one would draw from the fact that pulp fruits in general have smooth skins, or skins with at most a delicate bloom quite lacking the texture of the peach's almost woolly covering.

The Marriage of Cousins

In any event, there can be no question that the peach and the nectarine are very closely related; in fact, they are generally classified as a single species, the trees differing very slightly in any respect, the only difference being in the fruit.

It is probably but a short time, as compared with the entire stretch of their racial histories, since the two fruits branched from the same stem. And so it is quite to be expected that the two would readily cross. In point of fact, the experiment of cross-pollenizing is so readily performed that it is very often carried out by the bees.

The hand pollenizer may make the test successfully without the slightest difficulty.

I was led to experiment along this line perhaps by the recollection of an old peach tree called a "Melocotoon," four of which stood in our home garden in New England, and one of which had a single branch high up in the tree that always bore a fruit quite different from the peaches with which its other branches were laden. This anomalous fruit, which appeared as a "bud sport" was in fact a nectarine.

I had learned also that when peaches and nectarines were grown in the same neighborhood, one could never be certain as to which fruit would grow when the seed of either fruit was planted.

You may plant a peach seed and grow a nectarine tree; or, less frequently, you may grow a peach tree from a nectarine seed.

The explanation, of course, is that the two tribes are constantly intercrossed when growing side by side, through the agency of the bees.

According to these facts, I made some very definite experiments in hybridizing; first selecting for the experiment the white nectarine and the Muir peach. In 1895 numerous crosses were made, using principally the white nectarine pollen to fertilize the blossoms of the Muir peach, a very hardy, vigorous, abundantly productive variety of the peach that is largely cultivated in California.

The white nectarine has a superior rich flavor, but it is too acid to eat without cooking. It is of large size, has a large stone and white flesh, with perfectly smooth white skin. The Muir peach, on the other hand, is very sweet, with firm yellow flesh, and an unusually small free stone. A tree of this variety is unusually hardy, long-lived, immune from that pest of the peach orchard, curl leaf and may be grown in a large variety of soils in locations where other peaches and nectarines often fail.

The offspring of this union of nectarine and peach in due course came to fruiting age, and in some cases the fruit they bore was found to be of a quality superior to that of any peach or nectarine ever before seen. In the second and third generation there appeared a varied company, showing remarkable new combinations of qualities, and anomalies of form, size, color, and flavor.

Many of them combined the sweet, yellow flesh of the peach and the acid quality of the nectarine, producing delectable and altogether novel flavors.

Smooth-Skinned Peach Hybrids

There are now large numbers of these cross-bred peach-nectarines on my place, some of them being of the fifth and sixth generation from the original crossing.

Some have a crimson leaf like that of the crimson-leaved peach.

Some that have the characteristic rough stone of the peach, retain the smooth skin of the nectarine. These constitute a smooth-skinned variety of peach such as the visitor with the aversion to fuzzy skin longed for.

First and last, these hybrids show almost all possible combinations of a score or so of qualities as to which the two fruits in their diverse varieties differ. Among these there are some that are of the most exquisite combination of perfect qualities. "Quality" and "National" are superior market and drying peaches.

The first member of the hybrid company to be sent out into the world was named the Opulent.

It grew on a vigorous tree that bore abundantly even when quite young, and produced a

full crop of superlatively luscious fruit each season, ripening here about July 30th. The fruit has a white skin with numerous beautiful dots and shadings of light and dark crimson, and the flesh is pale lemon yellow, being a blend of the deeper tint of the Muir peach and the white flesh of the nectarine. In flavor the fruit has an indescribably delicious quality that surpasses that of all other peaches. But it is too soft for long shipment, although having all the desirable qualities of a home fruit. The Opulent has been acknowledged by all who have tested it to be the best in quality of any peach ever produced.

The tree is quite hardy. It has been cultivated as far north as Canada and has proved able to endure a temperature of 40 degrees below zero, bearing a full crop after other peaches in the same locality were destroyed by the severity of the winter.

Among the numerous seedlings from the Opulent, some are white nectarines pure and simple, some are red or pink nectarines, and some closely resemble the Muir peach. Yet there are many that differ from any known variety of peach or nectarine.

Similar results have been obtained in a subsequent series of experiments, in which the white nectarine was crossed with the early Crawford

A NEW SEEDLING NECTARINE

The nectarine is in effect a smooth-skinned peach. It is believed that the two fruits are really identical, and have only somewhat recently been modified through selective breeding. Nevertheless, there are some obvious differences in the peach and the nectarine, opportunity for interesting experiments in crossbreeding. (Two-thirds natural size.)

and peaches of other varieties. These crosses produced some seedlings of unusual size and good quality. The trees are nearly all resistant to curl leaf and mildew. As might be expected, the seedlings from succeeding generations differ widely. While nearly all possess one or more very desirable qualities, it is only occasionally that one combines enough good qualities to entitle it to special consideration.

The Union of Peach and Almond

Another series of hybridizing experiments, begun about twenty-five years ago, used for the original cross the purple-leaved peach and the Languedoc almond.

In the first and second generations, the four or five thousand seedlings produced had green leaves like the almond. In the succeeding generation, however, there appeared a few seedlings having purple leaves suggestive of those of the peach ancestor. A particularly dark one was saved. As is usual with the peach and almond hybrids, this tree was very fertile. One season I obtained more than 500 fruits from it. In every respect this fruit was intermediate between the peach and the almond.

About nine-tenths of the seedlings grown from the fruit of this purple-leaved hybrid had purple

leaves like the parent plant; most of the others had leaves of pure green, but a small proportion showed leaves of an intermediate color.

Looking at the row of seedlings from a short distance one would hardly perceive anything but a line of deep crimson or purple. Some of the individual seedlings were much darker than the parent, being fully as dark as the original purple-leaved peach. Most of the seedlings resemble the peach in foliage, but some have longer and more pointed leaves like the almond parent, and these generally grow more rapidly than the others and have a more upright appearance, in this respect also resembling the almond.

Although the exact parentage of the hybrids of the later generations of this combination of the almond and the purple-leaved peach was not traceable, and although no close record was kept of precise numbers, it will be obvious that the result of the first cross showed that, as between green leaves and purple leaves, in the relations of these two species, the influence of the green leaf was prepotent or dominant, as would of course be expected as green is the normal color of leaves, and purple exceptional.

The reappearance of the purple leaf in later generations is, of course, precisely what would be expected of a recessive character.

In any event the reappearance of the purple leaf, fully pigmented, after its submergence, affords another interesting illustration of the segregation of hereditary characters that we have repeatedly had occasion to note in connection with other experiments.

Cousins from the Orient

Continuing the experiments in peach betterment, it was natural to turn to the Orient for the material for further experiments in crossing.

There is a double-flowering peach that has long been under cultivation in China and Japan. It is a slender, willowy tree, generally with drooping branches. The blossoms are about an inch and a quarter across, snowy white, or pink, or deep crimson. They are quite double, resembling little roses, and are produced in great profusion. The trees, however, are dwarf and ill-shaped; they are also peculiarly subject to mildew and curl leaf.

The fruit of the flowering peach is somewhat almond-shaped and unusually pointed. It has flesh of light color and a large stone. The fruit is hardly edible even when cooked.

I have taken particular pains to cross this double flowering exotic with standard and the new crossbred peaches, and have succeeded in

producing some fine varieties. The most striking result, to date, is a tree bearing a rich, rosy, pink blossom, fully two inches in diameter, which is produced in greatest abundance, on trees of strong growth, which show no propensity to droop like the oriental tree, and which appear to be resistant to curl leaf and mildew.

This large, vigorous, healthy tree, bearing a profusion of bright pink flowers, has very unusual ornamental value. But, in addition to this, this new variety bears an abundance of fruit, large in size, and almond-shaped, which is of fairly good quality when fresh, although scarcely to be compared with standard peaches, but which when cooked is probably unsurpassed by any peach, having a delightful almond flavor.

This particular variety is a cross of the crimson-flowering oriental peach and the hybrid Muir peach, and is a product of the first generation.

Especial interest attaches to the results of crossing the oriental peaches with peaches of the occidental stock because, as in the case of so many other fruits, the peach of the Orient is widely divergent from the European type, although doubtless both have the same remote origin. As in the case of our other chief fruits, the native home of the peach was doubtless southern and central Asia and eastern Europe, and

there was a double migration in prehistoric days which resulted in stocking China with peaches of one type and Europe with quite another.

The peach most commonly grown in the United States is usually spoken of as belonging to the Persian race. The Chinese type of peach has been variously tested in California, and for the most part found wanting. The chief defect of the oriental variety is the pointed almond shape of its fruit, and susceptibility to mildew and curl leaf.

It will be recalled that the oriental pear showed precisely the qualities of hardiness and resistance to disease that the oriental peach notably lacks. The difference, in all probability, is to be explained by the different treatment the two fruits have received in their Asiatic home. The pear has been developed for its fruit, and the oriental taste demanded certain qualities of firmness and perhaps slight astringency that might be said to be in keeping with the natural character or propensity of the wild fruit.

But in the case of the peach special development has taken place along the line of flower production. Doubtless more attention has been given to this than to the question of fruit. And as with most specialized races of plants, there are incidental defects due to the selective breed-

THE EXQUISITE PEACH

This perhaps comes as near to the ideal of what a peach should be as any fruit ever grown. It was produced and introduced many years ago, and was of the same nectarine-peach ancestry as so many of my best seedlings. (Natural size.)

ing for a single quality and the overlooking of other qualities.

But whatever the explanation, the fact remains that this species of the Chinese peach is not to be looked to as introducing the elements of hardiness and virility.

Nevertheless in the Southern States the Chinese peach, which seems to be of tropical origin, thrives and is even quite as popular as the Persian strains.

Fortunately some of the varieties of the European stock are vigorous and hardy growers. But the development of new varieties that will be absolutely resistant to the diseases to which the peach is peculiarly subject is a task that invites the plant experimenter. I have already referred to the success in this regard that attended some of my hybridizing experiments.

My new peaches, named respectively the Leader and the National, both of them crosses of the Muir and Crawford stock, have been entirely free from any suspicion of mildew or curl leaf.

But there is demand for a great variety of peaches, and it is highly desirable that the average stock of this important fruit should be greatly improved in regard to virility.

That the peach may under favorable conditions live to an old age and continue in bearing is dem-

onstrated by exceptional trees that are known to be a half century old, yet still retain their vigor and productiveness. When we contrast with this the familiar fact that the average peach orchard bears only for a relatively short term of years—often only ten or fifteen at most—the vast economic importance of this possible improvement will be quite obvious.

A Stoneless Peach?

As to the fruit itself, there is one opportunity for improvement that is particularly inviting—the possibility of producing a stoneless peach.

The desirability of such a development, from the standpoint of the peach consumer, requires no demonstration. From the standpoint of the tree itself, a reduction in the stone would be highly important. It costs a peach tree to produce a pound of stones probably as much as to produce twenty or thirty pounds of pulp.

The drain on the vitality of the tree in producing the stone that it no longer needs must take from it in a large measure the capacity for production of fruit pulp that it might otherwise have and also from the vigor of the tree.

The hybridizing experiments with the almond have influenced the stone of the fruit in a sug-

gestive way. Some of my hybrid peaches have a kernel that is almost as sweet and edible as the kernel of the almond. As yet I have not secured a peach having really superior quality of flesh *combined* with the edible seed. But that this combination might be effected, if one were to select for it, admits of no question.

And a peach retaining its recognized qualities of flesh and having at its center an edible nut like the almond with thin shell would obviously be a desirable acquisition.

Such a combination of fruit and nut would be doubly desirable if the stone that surrounds the kernel can be eliminated as it has been eliminated in the stoneless plums.

As yet very little has been accomplished in this direction. There is, to be sure, a Bolivian peach which is remarkable in that it has a globular stone very little larger than a good-sized pea. The fruit itself is of intermediate size and poor quality; moreover, it is produced sparsely, and the tree is peculiarly subject to the peach maladies. The fruit has been thought hardly worth crossing with our ordinary peaches on account of its inferior qualities, yet the diminutive stone suggests that it would be possible by such crossing to produce a superior peach having an exceedingly small stone.

Time and patience would, of course, be required to carry out such an experiment, but its results could hardly be in doubt.

It is possible, however, that the experiment of reducing the size of the peach stone will prove less inviting than the attempt to remove the stone altogether. My success in producing the stoneless plum points the way to a possible development through which the peach also may at some time become stoneless.

And it is not unlikely that the Bolivian pea-stone peach, which has so greatly minimized the stone, may be utilized advantageously in the course of these experiments.

It is true that no stoneless peach of any quality is known, like the original wild bullace of Europe that gave the opportunity in the development of the stoneless plum. But, fortunately, I have been able to demonstrate that the peach may be hybridized with the plum. I have made the hybridization successfully with both the Japanese plum and the Chickasaw plum.

Should it prove impossible to combine the peach directly with a stoneless plum, one of these peach-plum hybrids might perhaps be made to bridge the gap.

No doubt a vast deal of ingenuity would be required to find the combination that would work

out successfully. But it was shown in the case of the stoneless plum that it was possible to reassemble the good qualities of the fruit of one parent and the stoneless condition of the other in the progeny of the hybrids of later generations.

There is no obvious reason why the same thing might not be done in the case of the peach.

The possibility seems the greater because the peach has been cultivated in so many different regions and for so many different purposes that it is highly variable. Its affinity with other stone fruits has been illustrated over and over in the story of hybridizing experiments already related.

So it seems at least within the possibilities that a way may be found to combine the stoneless condition which has now been bred into heredity of one member of the stone-fruit family, with the recognized qualities of the peach, in a hybrid—produced, no doubt, only after a series of experiments extending over many years—that will represent the ideal of a stoneless peach.

If the qualities of the almond seed were also bred into the combination, the final product—a fruit having the matchless flavor of the peach, a perfectly smooth skin, and a stoneless seed of delicious edible quality—would assuredly be the paragon of orchard fruits. That such a fruit will

ultimately be produced there can be little doubt. When we reflect on the long gap that separates the peach of to-day from its primitive wild ancestor, we need not regard such further development as that just suggested as being very formidable.

But, of course, there is a *time* element that cannot be ignored.

So here, as with other orchard fruits, it is only such experimenters as have the gift of patience who can enter the field with prospect of success.

Granted that endowment, however, and a reasonable comprehension of the principles of plant breeding already presented, any intelligent amateur may undertake experiments in the further education of the peach that may well lead to results of the highest interest and of notable economic importance.

The peach with its luscious meat, the nectarine with its smooth skin, the almond with its delightful kernel, and the stoneless plum with its unsheathed seed — who will breed these together and thus produce a unique and valuable fruit-nut?

THE APPLE—A FRUIT STILL CAPABLE OF FURTHER IMPROVEMENT

New Apples and How to Make Them

IF YOU were to look in Regan's book on the Nomenclature of the Apple you would find that about eight thousand varieties of this fruit are listed by name—not counting synonyms, of which each variety has several.

And you would receive assurance that the catalogue includes only such selected varieties as have attracted more or less attention in this country alone.

After scanning this list you might be excused if you felt disposed to turn your attention to some other fruit. An orchard product that already possesses eight thousand named varieties may not seem at first glance to offer a very good opening for the plant developer. It may reasonably be supposed to be a fruit that is already pretty well developed.

And in fact there is no disputing that the apple is a well-developed fruit. There are varieties of almost every supposable size and color and flavor and degree of early or late ripening, as the case may be, and of keeping quality. Yet it would be going much too far to say that nothing remains to be done. There are plenty of opportunities for the plant developer in dealing with this fruit, as I shall attempt to show in a moment.

But before taking up that aspect of the matter in detail it will be worth while to clarify the situation by a few words of comment as to the eight thousand varieties of apples that make such an imposing array on the pages of the cataloguer.

Varieties Versus Individual Types

The average purchaser and consumer of fruit probably has very vague notions as to what is the real status of the particular variety of apple that especially appeals to him.

He finds his favorite fruit—be it Baldwin or Northern Spy or Greening or Gravenstein or what not—in the market year after year at a given season. He sees that each fruit is always of approximately the same size, and color, and flavor. The differences between the named varieties are so radical that they could not possibly

be overlooked. A greening apple, for example, bears much less superficial resemblance to a snow apple than it bears to a quince; and the average purchaser might be excused if he supposed these two apples, along with numberless other specialized varieties, to represent forms as distinct from each other as, let us say, blackberries are distinct from raspberries or oranges from lemons.

But in reality the status of even the best market "varieties" of apples is quite different from this. It would scarcely be an exaggeration to say that each "variety" of apple manifests the peculiarities of an individual rather than those of a race.

We have already had our attention called more than once to the fact that the apple, in common with most other cultivated fruits, does not breed true from the seed.

It has been pointed out that we could not secure an orchard of Baldwins by planting the seeds of the Baldwin.

In a word, the fact has been emphasized that the conventional and necessary method of propagating the different varieties of apples is by budding or grafting, or by the equivalent method of sprouting slips or twigs. And attention has furthermore been drawn to the fact that this method of propagation may be regarded as the division

A BEAUTIFUL SEEDLING APPLE

Every orchardist is aware that seedlings grown from any standard variety of apple may show the utmost diversity of size, form, color, and flavor. Anyone may begin breeding experiments with the apple by planting seeds of any superior stock. There will be abundant opportunity for selection among the seedlings. The present picture shows one of the most beautiful seedlings, and the quality sustains its outside promises.

of an individual that has the property of restoring lost parts and continuing its growth indefinitely rather than propagation through a succession of generations.

It has been suggested that all trees that represent a particular variety of cultivated fruit—say all Baldwin apple trees or all Seckel pears—are separated parts of the original tree of corresponding variety, and not descendants of that tree.

Holding to this point of view, then, it is clear that the different "varieties" of apples should, from a biological standpoint, be classified as individuals rather than as races.

Their inability to reproduce themselves in offspring through the ordinary processes of generation denies them the rank of races or varieties proper, let alone the rank of species.

And after all the difference in appearance between two apples that rank in the catalogues as specific varieties is not greater than we sometimes see manifested between brothers and sisters of a human family. A man more than six feet tall with florid complexion, light blue eyes, and flaxen hair, certainly represents a type quite different from that represented by a woman less than five feet tall with swarthy complexion and black eyes and hair. Yet we sometimes see such

divergences as these between a son and daughter of the same parents.

Origin of the Diversified Types

We shall gain a somewhat truer conception of the meaning of our apple catalogue, then, if we think of each listed variety as having the status of an individual rather than that of a race.

The diversity of individual types becomes explicable if we consider the history of their development. The apple has been under cultivation for some thousands of years. It has qualities that have made it a favorite with successive generations throughout the entire period. It has been taken everywhere with migrating races of men—it was brought to America, for example—until it girdled the globe and found its way almost to the Arctic Circle.

The different races of apples thus developed have been from time to time intermingled through migrations of the peoples who cultivated the fruit, many of whom, doubtless from the earliest period, carried it with them in a dried state on their voyages, and thus perhaps incidentally transported its seeds and carried it into new regions.

The varieties thus brought together have been cross-pollenized by the bees, and so the tendency

to vary and to keep a great variety of ancestral traits in evidence has been perpetuated.

Finally, in modern times there has been perhaps more attention given the apple by the horticulturist than to any other single orchard fruit. The qualities of the apple and its adaptation to all tastes, zones, and soils naturally account for this. And the result is recorded in the present-day lists of the cataloguer. Whenever, through the chance blending of favorable ancestral strains an exceptional individual has appeared, cions have been cut from that individual and grafted on other trees, and new cions cut from this and again grafted, until the fruit of this individual grows on so many different trees and in so many different regions that its peculiar qualities are thought of as representing an established variety rather than an individual personality.

But if you will gather the seed from the apples of a single tree of even the best market "variety" in any given season, and will plant these seeds, you may have, when the seedlings come to fruiting, new "varieties" of apple, each differing from all its fellows, in such profusion that you may, if you so desire, exhaust your ingenuity in finding new names and publish a catalogue of your own with a list of eight thousand or so "varieties" of

apple that no one hitherto has ever seen or heard of.

That simple but rather startling fact brings into sharp relief the difference between the meaning of the word "variety" as applied to such a fruit as the apple and the meaning of the same word as applied to races of plants in a state of nature.

The seed of a plant of a valid wild variety (subspecies), or the seed of a hundred plants of that variety intermixed, will produce a generation of offspring which, though they number thousands or millions, all bear striking resemblance in their essential qualities of shape and leaf and flower and fruit to the parents from which they sprang and to one another.

This is the fundamental difference.

It is a difference that should be borne constantly in mind when we use the convenient word "variety" in connection with an orchard fruit. Perhaps it is unfortunate that the word has been applied with this double meaning; but it is obviously convenient, and if properly interpreted it may be used without danger of confusion of ideas.

From Germ Cells to Apples

That the potentialities of numberless new varieties lie hidden in the pollen grains and ovules

of a single flower cluster is a thought that makes strange appeal to the imagination of the intelligent plant developer.

When he pollenizes a flower he is bringing together two germinal microcosms each of which, rightly viewed, is a universe within itself.

He is dealing with individual life histories and with the histories of races.

He is performing, as I said before, the most marvelous of all experiments.

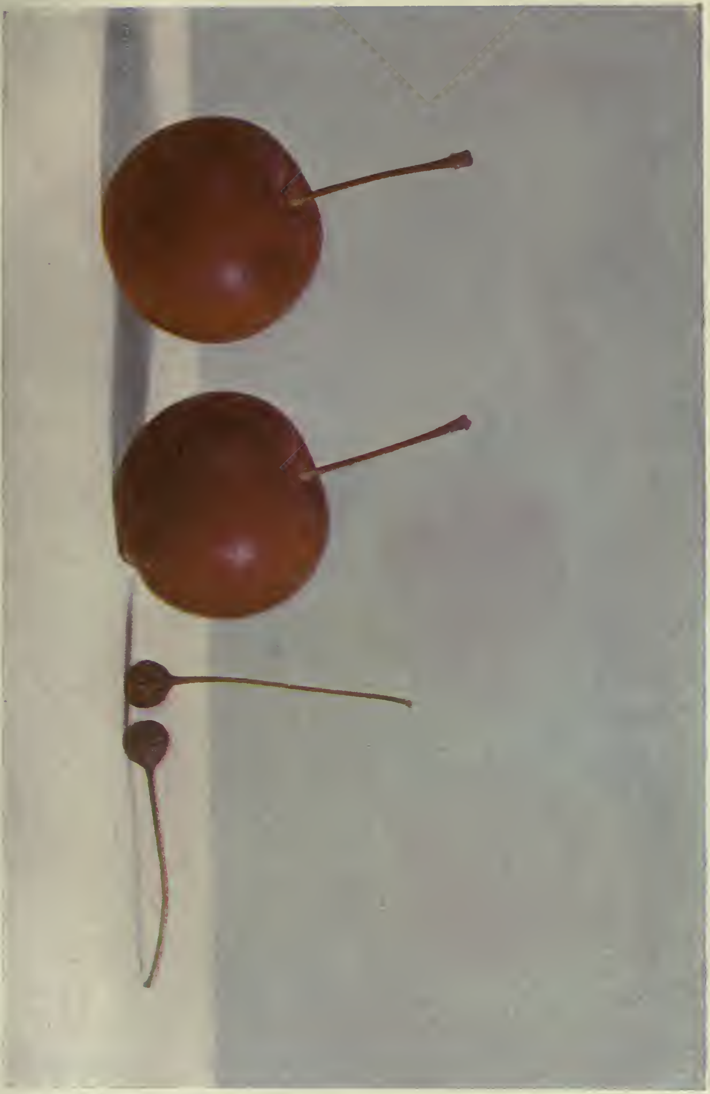
He deals with the same matter with which the chemist deals in his laboratory; but with this matter aggregated into new and wonderful combinations which alone make possible those responses to the environment and that primeval capacity for growth and of self-reproduction that differentiates what we call living tissue from the matter out of which it is constructed.

But if the plant experimenter must be allowed to indulge in such visions he must none the less remember that the microcosm of the germ cell represents after all only a transitory and transitional phase in the life cycle of the organisms with which he deals.

He may ponder over the mysteries of the nucleus of the germ cell, but he cannot offer that nucleus for sale in the market.

THE CRAB APPLE

The figures at the left show the eastern wild American crab apple, those at the right the western species. It is possible that the better American fruits owe their relatively large size to the attention paid to their cultivation by the Indians at a remote period. In any event, this fruit has qualities that make it a desirable parent in hybridizing experiments.



The tangible product of his investigations, the one that will have commercial importance, must find representation in germ cells that have infinitely multiplied until their descendants are piled together in such unthinkable numbers that they make up the structure of visible plants, and —to meet the exigencies of the case under consideration—of visible and tangible fruits of the orchard.

To be quite specific, and to bring us back directly to the practicalities of the subject in hand, the development of the germ cell must have led to the production of the particular fruit called the apple.

What, then, practically does there remain for the plant investigator to do in the apple orchard?

With eight thousand varieties of apples at hand, just how shall we come in competition and produce a new variety that will commend itself as having some points of superiority to any existing? Unless we can do that, it assuredly is not worth while to cumber the market with a new apple. There are enough inferior fruits already in the field. Let us by all means refrain from adding to their number.

What has been said suggests that the task ahead of us, in the perfectionment of the apple, does not lack difficulties. As a tangible illustra-

tion of the extent of these difficulties, I may note that I have grown on my experiment farms not fewer than 200,000 seedling apples, from the *best standard varieties,* since 1886, when I first definitely turned attention to this fruit; and that out of the entire number a single dozen now stand out somewhat prominently as being superior.

There are others, to be sure, not yet come to the fruiting age, that may surpass any yet produced in a combination of good qualities. Some of the individuals improve in certain points from year to year, and reveal new strength in certain valued characters, while others may fail to fulfill their early promise. The test must extend over a series of years, after the trees have commenced to bear, and each new strength or weakness in every direction must be noted with unflinching fidelity for many seasons.

With the record of my own experiments as a guide, let us briefly glance over the field, to gain such clues as we may to the opportunities that still lie open for the betterment of this fruit.

A Few Practical Hints

Great emphasis has been laid on the fact that apples do not breed true from seed. It should be noted, however, that some varieties are much

more nearly fixed than others. The Fameuse, Gravenstein, Garden Royal, and Golden Russet may be named among those that tend to reproduce a good many of their characteristics in their seedlings. Yet from any of these there may be produced apples showing almost every possible variation as to size, shape, acidity, flavor, and color. And so the growth of seedlings will be undertaken only for the purpose of securing new variations or to supply stocks on which to graft cions from old ones.

In raising apple seedlings to obtain improved varieties it is best to select seed from some one standard apple that already possesses most of the good qualities sought in the improvement, because comparative tests are more easily made from one variety than from mixed seed. There is much variation among different varieties as to keeping qualities of the seed and the characteristics of the seedlings. Seedlings of the Baldwin, for example, are peculiarly subject to mildew; seedlings of the Newtown are usually rather slow and slender growers.

As a general rule it may be said that the seeds of winter apples have a greater tendency to produce winter apples than summer apples, whereas summer apples are almost as likely to produce

THREE SEEDLING APPLES

These seedlings, particularly the one at the left, show the influence of the Gravenstein parent. They are of complex heritage, however, and have many characteristics that cannot be traced to the Gravenstein. The specimens here shown represent an intermediate stage in the breeding experiments, and have not been introduced or named.

winter varieties as to reproduce their own qualities as to time of bearing.

Sweet apples are quite often produced from the seeds of sour ones and vice versa.

The Yellow Bellflower produces a large proportion of seedlings good in most respects, and this is true also of the Newtown Pippin, Hubbardston, the Rhode Island Greening, Roxbury Russet, Haas Queen, William's Favorite, Swaar, Rambo, Fameuse, Lyscom, Alexander, Palmer, and Wagener. Especially fine seedlings have been obtained from the Garden Royal, Fameuse, Golden Russet, Wagener, and in particular the Gravenstein and the Newtown Pippin. Usually the weak point in Northern Spy seedlings is poor quality, notwithstanding its own exquisite quality.

One can be almost certain of producing some early bearing seedlings which will yield fruit of good quality, though lacking in size, from the Golden Russet, Garden Royal, or the Fameuse, and without raising a great number of seedlings.

Apple seeds, like all other fruit seeds, germinate more readily if not dried too thoroughly. The best method is to place them when fresh after thorough cleaning, in a box of slightly moist sawdust or coarse sand, moist enough to keep the seeds from drying, but not moist enough

to cause germination or to induce decay. Kept in this way in a cool place until desired for planting, they will germinate with unusual vigor.

If the apple seeds are wanted in large quantities, crush the fruit in a cider mill and wash the seeds from the pomace. When only a few seeds are to be taken from rare specimens of apples, the seeds are usually removed by hand. The seeds may be planted in the open field as early as possible in the spring in rows three or four feet apart, if cultivation is to be done with tractor or horse. Ten to fourteen inches apart is sufficient space for hand cultivation.

Details as to methods of planting and care of the seedlings have already been given in a separate chapter and need not be repeated here. No special cultural directions are required in growing the apple seedlings. They are cared for on my farms very much as peas and beans are cared for, and they are as easily grown, when the seed has been kept in good condition.

It is best, however, to inspect the young seedlings often and to remove all weak or slow-growing ones and those having slender stems and thin, small leaves; and in particular any that show the slightest evidence of mildew.

It is not desirable to treat seedlings that are grown for the production of new varieties with

fungicides; the persistent aim should be to produce trees that are thoroughly resistant to fungoid diseases.

The seedlings that show large, thick leaves and thick, fat, prominent buds placed not too far apart, combined with stocky, short-pointed, juicy wood, are the ones most likely to be valuable.

Let us emphasize again that in fruiting the seedlings an enormous amount of time and valuable space can be saved if they are grafted upon large bearing trees. I am accustomed to take one or two good cions from each of the selected seedlings at the end of the first season's growth, grafting them into a bearing tree on branches a quarter inch or at most a half inch in diameter. Thus placed, they will begin bearing in from two to four years; whereas if placed upon the large branches a much longer period would be required.

By this method I have tested as many as 526 varieties by actual count at the same time upon a single tree.

Thus twenty thousand or more varieties may be tested at once on a single acre. The same trees may serve in this way over and over indefinitely.

It would be well if fruit growers in each geographical section would raise and test new seed-

NAMELESS BEAUTIES

These seedlings are also nameless, although they would merit introduction were it not that there are already so many excellent varieties of apples on the market. As it is, they have proved useful in further crossbreeding experiments.

lings, and also introduce and experiment with new varieties produced elsewhere, aiming always to select those best adapted to the requirements of the particular locality. In this way many localities where the apple cannot be grown to-day might produce thriving orchards.

Making Hardy Apples

The apple is relatively hardy, but improvement is still possible in the way of producing varieties that will stand the excessive cold of our northern winters. The work of crossing hardy Russian apples and also the hardy American crab with the better varieties of apples is now being carried on quite extensively, especially in Iowa and South Dakota. By this means some good varieties have been produced that are especially adapted to withstand the extremes of temperature of the northern Mississippi Valley, and others are in prospect.

Especial efforts are being made, also, to develop varieties that will be immune to the attacks of the insect pest known as the woolly aphis, which does great damage in apple orchards, especially on heavy soils and in moist climates. This pest is relatively harmless to the tree tops, but does great damage when it infests the roots of a tree.

Because of the general immunity of the pear to the attacks of the woolly aphis, I have made many attempts to find a variety of pear that would serve as stocks on which to graft apples. In a very few cases the grafts have taken well at first, but the final result was a failure, from a commercial standpoint. It is possible that a variety of pear will eventually be found which will be congenial to the various varieties of apples; and, if so, the problem of combating the woolly aphis will have been solved. There are now several varieties of apples partially or wholly resistant to this pest.

My experiments consisted in growing seedling pears to get new varieties on which to graft the apples. This is probably the only way to approach the subject, for attempts have been made with practically all the existing varieties of pears, and in every case the result has been failure.

Fortunately there is one well-known variety of apple, the Northern Spy, that is aphis-proof. Trees of this variety are never injured by these insects, even when planted beside trees seriously infected. It has been found expedient, therefore, to graft other varieties on roots of the Northern Spy, and an orchard that has practical immunity to the attacks of the aphis may thus be produced.

Unfortunately the seedlings of the Northern Spy rarely inherit this quality of resistance to the aphis, so it is necessary to grow the roots from cuttings.

Apple twigs do not root very readily, but if cuttings from vigorous Northern Spy trees are placed in the soil and allowed to grow for a year or longer they develop a good root system and the roots may be severed into small pieces, each of which will produce a stock upon which grafts of any variety may be placed.

Hybrid Apples

I have experimented very extensively, as already noted, with the crossing of different familiar varieties of apple, and have produced several new varieties that have been deemed worthy of introduction.

But my most interesting experiments have had to do with the wider hybridization in which one or another variety of cultivated apple has been crossed with a related species. In endeavoring to introduce new traits I imported in 1890 all of the best varieties of apples theretofore originated in Australia and New Zealand.

It was necessary to graft these cions onto older trees to test the fruit, and some very curious results were observed.

GETTING ON IN THE WORLD

Three big crossbred Burbank apples are here shown in comparison with three tiny wild apples, the latter probably not very different from the parent forms from which the cultivated apple originated. Note the similarity in the outward appearance of the fruit, notwithstanding the enormous disparity in size.

Most of these new varieties from another hemisphere appeared to be surprised to find the winter over so soon and the spring now opening upon them. Some varieties immediately put out buds and blossoms and continued to do so at intervals throughout the summer; others stubbornly declined to bud or blossom until nearly the beginning of the following spring. For two or three years thereafter all seemed quite confused and disturbed by the transposition of the seasons; but ultimately they became adjusted to the new order of things. One or two of them have proved to be unusually fine apples, and are now thriving well in northern Sonoma and Mendocino Counties.

About 1894 I began experimenting with our native western crabs, crossing them with pollen of our best cultivated apples, more to see what would result than with any expectation of securing improved commercial varieties.

One striking result was produced by using the pollen of the Gravenstein. Numerous seedlings were thus produced from this little native crab. Strange to say, among the seedlings of the first generation was an apple which was fully as large as the Gravenstein and very much like it, except that, though quite good for a short time just before ripening, it changed rapidly to a punky or

mealy state. Others were about halfway between the two species in size, color, quality, growth, and other characteristics, both of trees and fruits in all variations.

But among the second-generation seedlings raised from these hybrids some fairly good apples were produced. In form, some almost duplicated the Gravenstein itself; very few of them resembled the true wild crab type, except that nearly all had a certain crablike acidity and lack of flavor.

Some of these hybrids are still growing on my Sebastopol farm. No one of them gives promise of being worthy of introduction, but it is not unlikely that something of value may be developed from this stock by further hybridizations and selections. The wild crab has certain qualities of hardiness and prolific bearing that might be of value in combination with the fruiting qualities of some cultivated variety. This, at all events, is a line of investigation that offers opportunity for further tests.

Doubtless the most interesting of these hybridizing experiments with the apple tree are those in which this species was crossed with the quince and with the pear.

I have grown numerous seedlings from a cross of the apple and the common quince, *Cydonia*

vulgaris, and also the giant Chinese quince, *Cydonia sinensis.* This cross was made both ways in both cases. This is a cross between genera.

Some of these hybrid seedlings grew quite rapidly. The growth was generally unique, being compact and stubby, and often with an unhealthy appearance, especially toward the last of the season. The foliage and bark most often resembled the quince.

I hoped for good results from these interesting hybrids, but not one ever produced even a blossom. The developments were the same in all seedlings, however the cross was made. After a few years many of them would decline and die, whether grafted on the quince or the apple or growing on their own roots, like some berry hybrids which will be mentioned later.

Several varieties of apples were also crossed with the Bartlett and other pears. This is also a bigeneric hybrid, and the result was in the end similar to that of crossing the apple and the quince. Most of these seedlings were abnormal in their growth. They were generally dwarfed, but in some cases exceedingly rapid growers were produced, especially when the Bartlett pear was crossed with the apple. But none of them gave any indication of producing blossoms, to

HALF-SWEET, HALF-SOUR APPLE

This picture shows the curious effects that sometimes result from the natural or artificial cross-fertilizing of two fruits. As a rule cross-fertilization does not show its results immediately in the fruit, but only in the progeny. And in this case the tree bearing this apple also bore pure red and pure yellow apples on the same branches with those having variegated sections of different widths.

say nothing of fruit. These, like the quince-apple hybrid seedlings, being only cumberers of ground which was needed for other purposes, were destroyed.

It will be seen, then, that nothing of practical importance came of experiments in hybridizing the apple with its remoter cousins. Nevertheless the proof that such hybridization is possible must be regarded as highly interesting. It seems by no means unlikely that further tests along these lines might result in revealing some varieties of these various fruits that would combine more advantageously and produce fertile offspring.

As mentioned in another connection, there is perhaps no opportunity open to the amateur fruit grower that suggests greater possibilities of really important discoveries than this. Out of a union of apple and quince or apple and pear might very possibly come a new fruit that would constitute an acquisition of the very greatest value.

But even if the practical or economic results should prove meager, such a series of experiments might still have a large measure of scientific interest, more than justifying the time and labor devoted to them. So very little work has hitherto been done in this line, that the field may

be said to be almost virgin. Opportunity beckons the plant developer very alluringly.

And, fortunately, this is a case where the material for experimentation is freely available. Apples, pears, and quinces grow in thousands of dooryards. Thousands of men and women might test their mating possibilities. There will be the stimulus of novelty and the lure of unknown goals in such an unusual endeavor.

There are eight thousand named varieties of the apple, and yet who shall estimate the uncounted opportunities for further apple improvement?

THE TRANSFORMATION OF THE QUINCE

What Was Only a Cooking Fruit Now Delicious Raw

HENRY WARD BEECHER once gave a formula for cooking the quince. His rule was this: Take one quince, one barrel of sugar, and sufficient water.

This rule was given, I hasten to explain, at a time when my Pineapple, Van Deman, and other quinces had not been developed.

Had Mr. Beecher tasted one of these perfected quinces he would have seen that his joke no longer had its former force. For my Pineapple quince, and one or two others that have been developed even more recently, retain none of that acrid quality which Mr. Beecher's barrel of sugar was designed to remedy.

On the contrary, the new quinces, when fully ripe, are to be compared in texture of pulp and in edibility with some of the best apples; and at the same time they retain in greater degree the

matchless flavor that made the quince a favorite fruit for jellies and preserves even when its other qualities made it altogether inedible before cooking.

Indeed, the new fruit not only retains the indescribable but exquisite savor of its tribe, but has taken on quite pronouncedly the flavor of the pineapple, fully justifying its name in the estimate of those who have eaten it.

The transformation thus effected in the quality of the quince has been brought about through a series of experiments that began as long ago as 1880. When I first gave the matter consideration the quince, although it had been under cultivation for at least two thousand years, had been distinctly neglected by the horticulturist. There was a prevailing idea that the quince tree would thrive on neglect, and that the inherent qualities of the fruit were such as to place it hopelessly beyond the reach of experiment except as material for cooking.

But I could see no good reasons why the quince should not be improved somewhat as the apple and pear had been. Work was commenced by planting seeds of all the best strains of quinces, including among others the Orange, Angers, Portugal, Rae's Mammoth, West's Mammoth, and Champion. All of these are

varieties derived from the common species which the Romans called *Mala Cydonia*, or Cydonian apple, because an improved variety came to them from Cydon, in Crete. From this old Roman name we have at the present time for the common quince the scientific name of *Cydonia vulgaris*.

First Successful Matings

One of my earliest experiments was to cross the Orange quince with the Portugal quince.

The Orange type is generally much more productive than the Portugal, and the fruit is larger and more pleasing in form, being nearly round and comparatively smooth. It is also of a more attractive color. On the other hand, the pear-shaped Portugal quince, although having a heavy objectionable rusty coat, is of a better quality, having a very pleasing flavor when cooked.

It seemed certain that from the combination of these two varieties it might be possible, by subsequent selection, to produce a quince superior to either.

Seedlings from this cross of Orange and Portugal quinces were raised extensively for several years.

Large trees upon which to graft and test them all not being available, the selected ones were set out on the Sebastopol place rather

VAN DEMAN QUINCE

This was the first of my important quince productions. It was descended from an original cross between the Orange and the Portugal quinces. It took the Wilder medal at the meeting of the American Pomological Society in Washington in 1891; *and was named after Professor Van Deman, then head of the Department of Pomology of the U. S. Department of Agriculture. It is very prolific, hardy, and is regarded in many parts of the East as almost the only quince worth raising. Its productivity, size, shape, smooth skin, and attractive color are inherited from the Orange quince; its spicy flavor and tenderness from the Portugal.* (*About one-half natural size.*)

closely, in rows about 4½ feet apart. Although a thorough test could not be made in this way of all the varieties, it was possible to make a very fair comparative test. The poorer seedlings were from time to time removed, leaving space for better development of those that remained. Later some of the trees whose fruit was not promising were used as stocks on which to graft hybrid pears and other quince seedlings.

By this method I have tested probably seventy-five thousand quince seedlings.

The first important result of this experiment in crossbreeding was the production of a quince of large size from a seedling produced by pollenizing a Portugal quince with the Orange quince. Among my seedlings one individual showed marked superiority over its fellows even in the seed bed, by its unusual vigor and the rich green of its large, finely formed foliage.

Among the entire lot of 700 crossbred seedlings this one alone proved really valuable.

The fruit it bore received the Wilder Medal at the meeting of the American Pomological Society at Washington, D. C., in September, 1891. It was so generally admired and promised to be so valuable that Professor H. E. Van Deman, then Chief of Division of Pomology, U. S. Department of Agriculture, was pleased to have it

named for him. The Van Deman quince inherits great productivity, size, nearly globular shape, smooth skin, and attractive color from the Orange quince, while it received its spicy flavor and tenderness from the Portugal. It has continued to be extremely prolific and an unusually strong grower, and at the present writing, 1921, it is quite generally pronounced better than any quince before known except my "Pineapple," which is the best quince in all respects at the present date, and the only quince really worth raising in the Eastern States. It has proved to be of remarkable hardiness and productiveness under the most adverse conditions.

Under favorable conditions the Van Deman produces three distinct crops each season in California.

The first or main crop ripens on my experiment farm during the latter part of September. The fruit of this first crop is of extremely large size, often being over five inches in diameter, and weighing twenty-five ounces.

The second crop ripens about November, and the third a month later. With these later crops the fruit is much smaller. But all are of good flavor, texture, and quality. They bake as quickly as some apples, and are tender when thus prepared.

The dried or canned fruit retains the much desired quince flavor.

At the time when the Van Deman quince was introduced, in 1893, I had growing for comparison trees of all the other varieties above mentioned. But no one of them bore fruit at all comparable to the new variety.

The new tree, in addition to being a very prolific bearer, also had the habit of early fruiting.

Trees two years old quite commonly bear fruit.

From Florida a Van Deman quince is reported that took on eight feet of new growth within one year from the time of planting. In Washington two trees in their third season bore twenty fine quinces weighing from twelve to fourteen ounces each as their first crop, and a little later a second crop declared to be quite equal to the other.

Seedling Tests and New Crosses

I had, of course, made crosses between various other varieties in the quince orchard and in due course developed other seedlings that showed valuable characteristics and had learned by experience to be able to select seedlings of the quince, as of other fruit trees, by observing the character of the leaf and stem.

Seedlings having leaves that are large, thick, dark green, and glossy, and that show prominent rounded buds and upright branches with thick, bright wood are those that may be expected to produce the largest and finest fruit.

Worthless seedlings are known by the opposite characters. Seedlings having small, knotted, twisted wood; slender, small, sharp buds; long joints; woolly, wild-looking leaves, and irregular rambling tendency of growth should be rejected, as they will very rarely produce fruit of any value.

There are notable exceptions to these rules of correlation between twig and foliage and fruit quality, but, as a rule, the qualities just noted may be depended upon to serve as most useful guides.

My second important new quince was grown as a seedling from Rae's Mammoth. It was, I am confident, a third generation seedling of a cross between Rae's Mammoth and the Portugal quinces. Its immediate staminate parentage is not a matter of record, as a great number of crossbred quinces were under observation at the same time, and specific record was kept only of the first pollinations.

This offspring of Rae's Mammoth was at first called the Santa Rosa, but was subsequently re-

christened by the introducer as the Child's quince. It is remarkable for its great size and productiveness, for beauty of form, and for its pale lemon yellow or almost white skin; also for the tender flesh and delicious flavor of its fruit, and the diminutive size of the core.

So fine-grained and tender is the fruit, and so free from the harsh acidity of the old quince, that it is equal to some popular apples for eating raw, and equal to the best apples or pears when baked, stewed, or canned. It will cook as tender as the best apple in five minutes. Moreover, it makes a superior light-colored dried fruit.

In form the fruit is somewhat intermediate between the Portugal and Rae's Mammoth, inheriting from both parents; but in quality it is far superior to either. This new variety has been rather extensively distributed in the Eastern States. The only complaint heard of it in the colder climates is that it does not bear so well as in California, but this is the case with all quinces. The soil and climate of California are peculiarly adapted to this fruit.

The Pineapple Quince

Attention has elsewhere been called to the fact that once a tendency to variation has been introduced by crossing among plants

PINEAPPLE QUINCE

This was my second important new quince, and was grown as a seedling from Rae's Mammoth, crossed with the Portugal quince. It is a remarkable for its great size and productiveness, for beauty of form, and for the tender flesh and delicious flavor of its fruit, and the diminutive size of the core. This quince is grown on the west coast in enormous quantities for export. No other quince compares with it in quality. (Poor specimen, about one-half natural size. The fruit is apple or globe shaped.)

of a given company, the effect appears to be cumulative.

Thus opportunity is often given in later generations for selections that will lead to relatively rapid progress along the desired line of development.

Such was the case with the quinces. As selection proceeded one generation after another, the tendency to improvement became more pronounced. The new varieties already secured were a very great advance upon their progenitors, but there ultimately appeared a seedling that produced a fruit far superior even to the very good ones already introduced.

This superlative variety, which appeared as the culminating product of fifteen years of selective breeding, was the one referred to at the beginning of this chapter.

Because of its peculiar flavor this new quince, as already stated, was named the Pineapple.

It is additionally remarkable for its early bearing and the great productiveness of the trees, for the large and uniform size of the fruit, which is moreover exquisite in form and of a pleasing light lemon yellow color, with freedom from the unsightly wool common to other quinces.

Everyone knows that the ordinary quince cannot be eaten raw with any degree of satisfaction,

nor with any expectation of personal comfort in the immediate future. Even children, voracious and unexacting as are their appetites, will scarcely eat a common quince.

But the Pineapple quince when thoroughly ripe rivals the apple as a fruit to be eaten raw.

It will also cook as tender as the tenderest cooking apple in four and one-half minutes. No other quince previously known can be cooked so quickly. It makes a delicious jelly with a strong, pure pineapple flavor. The jelly, indeed, is far superior to that made from any other quince, and in the estimate of many it is superior to that made from any other fruit.

The Pineapple quince, moreover, is the first variety to be profitably shipped from California to eastern markets.

In 1910 Mr. H. A. Bassford, one of the largest growers of California, shipped this variety in ordinary twenty-pound plum crates. The earliest shipments sold at auction for $3.50 per crate. Later shipments brought $1.50 per crate, and at the present date, 1921, the profits from its growth are unusual.

A Practical Shipping Fruit

I mention these practical details because the value of the quince as an orchard fruit for ship-

ment to distant markets has never before been recognized. Doubtless the forbidding qualities of the ordinary quince are responsible for this lack of popularity. But now that the Pineapple quince has been introduced there is an entire change of popular attitude toward this really admirable fruit.

I may add that I have even more recently found among the seedlings one that rivals the Pineapple, and which has qualities that fully justify its introduction as another new and distinct variety.

This newest of my quinces—called the Burbank—is somewhat larger than the popular Orange quince and of much better form. It is as smooth as an apple, having completely dropped the objectionable habit of producing wool on the skin. The tree is vigorous; it grows in fine form; and it is an early and astonishingly prolific bearer.

The fruit has the cooking qualities of the Pineapple quince, and is superior for drying and canning, and quite unrivaled except by the Pineapple for the making of jelly.

Testing Remoter Combinations

It goes almost without saying that I did not carry the work with the quince far before I

undertook to introduce new blood from more remote resources.

All the varieties hitherto named are descendants of European stock, and are of the same species. But the quince, like the other orchard fruits, has oriental representatives—races that migrated eastward from their central Asiatic home while the parents of the European quince were migrating westward. In China and Japan there are quinces that are listed as belonging to three different species, named *Cydonia sinensis, C. japonica,* and *C. Maulei.* All of these are quite different from the European quince as to growth, foliage, and fruit.

As early as 1884 I began making hybridizing tests with these oriental quinces.

Particular interest attaches to the experiments in which the first-named member of this oriental trio was used. This is popularly known as the Chinese cucumber quince, sometimes called *Pyrus cathayensis,* the Cathay pear.

In its general appearance this Chinese tree is a small, upright grower, quite unlike the ordinary quince. It is not hardy in the northern United States. The leaves resemble those of the apple or pear more than those of the quince, and turn scarlet in the fall. The flowers for which the tree is often grown vary from pink to crim-

son, making a gorgeous display in the early springtime. The fruit is variable, but is usually long, green, very hard, bitter, and uneatable however prepared, but quite fragrant.

In shape as well as in size the fruit suggests a large, full-grown, white-spine cucumber. It has usually a smooth, though sometimes netted waxy skin. A single fruit may weigh more than two pounds.

It will be clear from this description that the Chinese quince, or Cathay pear, differs very widely from the European quince. Its fruit is wholly inedible, yet there is no reason why this might not be made over into a profitable and delicious fruit. It is merely a fruit that has retained the qualities, undesirable from the human standpoint, of its remote ancestors. Perhaps it is not much worse to-day than the common quince was in the time of the Romans.

In hybridizing this peculiar fruit with the common quince I worked with an open mind, anxious to see what result the experiment might bring forth.

The pollen of the common quince was applied to the pistils of the Chinese species. Pollination was successful; the appearance of the young seedlings grown the following season left no

doubt of that. A glance showed that a certain proportion were hybrids, and even when they first broke the soil they presented much larger cotyledons of a different color from those of either parent.

These seedlings were carefully planted in open ground at Sebastopol with some uncrossed seedlings of the Chinese quince in the same row for comparison, the hybrids, however, being given the choice of soil and location.

We have previously learned that hybrids usually grow more vigorously than uncrossed seedlings, but the case of these quinces proved a very notable exception to this rule. At the end of two years the Chinese quinces of pure stock ranged from eight to twelve feet high, while the hybrids, which had been given more room and the best soil, were dwarfs only six inches high, some of them even less.

The foliage of these curious miniature trees was generally a composite, somewhat suggestive of each parent. But in a few instances plants showed leaves much shorter and more rounded than those of either parent, and having the edges coiled back in a semicircular form. This peculiar coiling of the leaves was probably due to the fact that the midrib was inclined to grow more rapidly than the edges of the leaf.

Unavailing effort was made for two years to stimulate the growth of these interesting hybrids.

The pure-bred Chinese quinces in the same row came in due course to the time of fruiting, but the hybrids showed no propensity to flower, and the tallest were less than a foot in height when their uncrossed relatives had grown to the height of ten or twelve feet.

Transplanting to orchard soil and special cultivation appeared to have no effect on the dwarfs. The experiment was made of grafting some of them into old quince trees of each of the parents. Some of the grafts grew and had rambling, spiral-shaped branches, but they stopped growing when they had attained a length of two or three feet. Grafting appeared to give them somewhat enhanced powers of growth, but, like the hybrid seedlings from which the cions were cut, they remained absolutely sterile.

No bush or tree of the entire lot ever put forth a single blossom.

Other Dwarfs Recalled

It is interesting to recall, in connection with the curious result of this experiment in hybridizing the quinces of widely varying species, the results of my hybridization of the California and Persian walnuts.

THE MEDLAR—A COUSIN OF THE QUINCE

The Medlar, known to the botanist as Mespilus, is a native of central Europe. There is a single species only, but there are several cultivated varieties. The fruit is too acid for most tastes, but after being mellowed by frost it is relished by those who care for acid fruit. It is hardy as far north as central New York in the Eastern States and of course throughout California. It is perhaps worthy of more attention than it has received from the American fruit developer.

It will be remembered that the hybrids thus produced were of extraordinary growth, but that they produced very few nuts, and that among the seedlings of the second generation there were many trees of dwarfed growth, suggesting the quince hybrids.

We found reason to believe that the curious result of hybridizing the walnuts might be explained on the supposition that the parent forms had diverged almost to the point of mutual antagonism. They had not varied quite to the point where their offspring were sterile, but they were approaching that limit.

The quinces of the experiment now under consideration had diverged one stage farther. They are still within the limits of affinity that permit cross-fertilization and intergrafting, but not within those that permit the production of fertile offspring. Their case is rather to be likened to that of our petunia and tobacco hybrids, which, as the reader will recollect, were lacking in virility and produced no blossoms. The similar case of the motley hybrids made by crossing various members of the rose family with their cousin the dewberry will be recalled. Also the strange progeny of the strawberry and the raspberry.

The Chinese-European hybrid quince, then, in its dwarfed growth and its sterility merely illus-

trates the principle of growth that we have previously seen manifested with various other plants.

But the extreme dwarfishness of the progeny gives an element of added interest. It would be worth while, could time be found for it, to make more extensive hybridizing tests along the same lines. Possibly some other strains of the two species than those employed might prove to have slightly greater affinity. In that case it is conceivable that a new race of quinces might possibly be produced that would bear fruit of a new character and give us an interesting and perhaps valuable addition to the rather small list of orchard fruits.

In this connection we may refer again to the experiments in which I hybridized the quince and the apple, and to others in which the quince and pear were similarly united. The story of these experiments has been told in earlier chapters, and no detailed account of them need be given here. It suffices to repeat that the hybrids in each case failed to blossom; hence that the experiment, quite as in the cross with the Chinese quince, came to no result of practical value.

But here, again, it should be borne in mind that more extensive experiments in hybridizing

these related species might give us a combination that would be slightly less antagonistic.

It goes without saying that a fertile hybrid between quince and apple or between quince and pear would be a fruit of altogether exceptional interest and of the most inviting possibilities. The experiment of hybridizing these common fruits may readily be made by the amateur, and there are few simple hybridizing experiments that are more attractive as to their possible results or more instructive from a scientific standpoint.

Test with Japanese Quinces

The two remaining oriental quinces have already been named as *Cydonia Japonica* and *C. Maulei*. It should be added that the latter is probably to be considered as a subspecies. Japanese quinces do not bear very freely, and their fruit has a great variety of forms, and is of such extreme acidity as fully to justify Beecher's celebrated formula.

There is great diversity of bloom among established varieties, the flowers ranging in color from pure white to bright scarlet and deep crimson. Some of them are double. The tree is raised for ornament only. The bushes are aflame with leaf buds early in the spring. A little later they

light the landscape with their gorgeous array of deep crimson, scarlet, pink, and yellowish or white blossoms. Again, late in the autumn, they are brilliant with bronzed leaves, and present fruits of curious and interesting forms.

This, obviously, is a very different tree from the common quince. It seems so distinct that I have never attempted to hybridize the two. But have crossed the various Japanese quinces among themselves.

The crossbred seedlings vary widely in foliage, blossom and fruit. Some of the fruit produced was as large as ordinary apples, and of varying shape. Where experiments were made with the species *C. Maulei,* there was greater promise than in the case of the other flowering quinces. This subspecies is a more abundant bearer than the others, and its fruit is of less objectionable quality.

The uncrossed specimens of this species are low, spiny shrubs, not more than two or three feet high, with short, stiff, spiny branches, which are often woolly when young. The bushes are multiplied readily by division; that is, from rooted suckers, which spring up from the parent plant. The flowers, which are usually borne in abundance, are of a bright orange-scarlet. There are races of the subspecies that have

variegated leaves tinged with delicate pink and white.

This type of flowering quince has much to recommend it as an ornamental shrub. Moreover, my hybridizing experiments, as far as they went, indicated that the *C. Maulei* has very valuable latent possibilities as a fruiting shrub.

From the many thousand seedlings many promising specimens were obtained. Some of these produced large, handsome, light crimson blossoms, and extremely large orangelike waxy golden fruit in the greatest profusion. These quinces, indeed, are among the handsomest of all fruits. They always attract attention by their peculiar form, golden color, and exquisite fragrance. The flesh, however, is usually hard and very acid, though not unlike some varieties of the common quince.

The extreme hardiness of this species, and its good productivity make it a very valuable parent for crossing with other allied varieties. It would be highly interesting and perhaps important to experiment in crossing these shrubs with the common quince. If the cross could be effected, it is not unlikely that very valuable betterments could be brought about. It is at least within the possibilities that a quince might be developed that would be superior in various ways to even

the best of the European varieties. But doubtless a long series of too expensive experiments would be necessary to attain this goal.

Whatever the precise steps through which the further development of the quince is brought about, there can be no question that this fruit has a very important future. It has been neglected in the past, and the fact of its tendency to vary toward the wild type demonstrates the comparatively slight improvement that has been made in it through artificial selection. But the production of the new quinces that I have described opens a broad new field in quince culture. The first steps in improvement have sufficed to show that the fruit is responsive.

The quince of to-day is, indeed, a half-wild product that has waited long for its opportunity.

It remains for the fruit growers of to-morrow, working with the product in hand, to see that the possibilities of this unique fruit are realized. So hardy, prolific, and generally attractive a tree should make especial appeal to the amateur orchardist. The fact that the quince has been neglected, and thus has abundant possibilities as yet unrealized, gives it additional attractiveness from the standpoint of the experimenter.

In case of apple or pear or peach we have to do with fruits that have been carefully studied

in thousands of experiments generation after generation. Even so, we have seen that there are still good opportunities for further experiment.

But how much larger and, so to say, more accessible are the opportunities in case of a fruit that has been generally ignored as has the quince. Why not avail yourself of these opportunities?

It remains for the fruit growers of to-morrow working with the partially developed product in hand, to see that the possibilities of this unique fruit are realized.

THE APRICOT AND THE LOQUAT

AN OPPORTUNITY FOR INTERESTING EXPERIMENTS

"THE only use I have for the apricot," said a visitor, "is to supply a flavor for soda water; but that use justifies the fruit's existence. No other flavor can match it."

Doubtless my visitor spoke facetiously, but we may all agree with her that there is no other flavor quite to match the flavor of the apricot. Fortunately, however, there are uses to which this splendid fruit may be put in addition to the one she suggested.

Otherwise it would not be possible to find a market for the two hundred and fifty million pounds or so of apricots that California raises each year.

In fact, the uses of the apricot are quite as varied as those of most other fruits.

It is an admirable table fruit in the fresh state for those who live near enough the orchards

to secure it. It is in considerable demand by canners who find ready sale for the fruit when preserved in this way. But the chief demand, and the one that gives the apricot its real economic importance is based on the exceptional qualities of the fruit when dried.

Something like three-quarters of the entire output of the California orchards is preserved in this way and shipped as dried fruit to all parts of the world, and brings about the highest price of any tree fruit under cultivation.

A perhaps clearer estimate of the value of the industry may be gained if we recall that there are more than three million apricot trees in California orchards. Indeed, this State has a practical monopoly of commercial apricot growing.

Nowhere else in the world is the fruit of corresponding economic importance.

The apricot has been cultivated from an early period of history, like the allied orchard fruits, and it has been grown more or less extensively in America for many years. But it is a fruit that is greatly restricted as to the regions in which it can advantageously be cultivated. The fact that there are very large areas of California where it thrives, sufficiently explains the virtual monopoly in the growth of this fruit that the Pacific Coast enjoys.

Why Apricot Culture Is Difficult

The difficulty that the apricot grower encounters may be said to center on a single characteristic of the tree—the extreme sensitiveness of its blossoms.

The apricot tree itself under proper conditions is relatively hardy and extremely productive. It is long-lived, and it attains great size. Moreover, it sends out a very extensive root system; demanding plenty of room, and justifying the demand by its increased production when the trees are not crowded. It continues to grow for many years, constantly extending its root system; so that some orchardists recommend planting the trees originally twenty feet apart and then, after a number of years, as the trees increase in size, removing every other one, thus securing a forty-foot space for the roots of each tree.

In the matter of pests that attack it, the apricot is relatively favored. It is on the whole a very healthy and vigorous, as well as very beautiful tree.

But the sensitiveness of its blossoms has hitherto put a restriction upon the spread of the tree beyond the subtropical areas, except in such a territory as that of California, where, because of exceptional topographical conditions, a sub-

APRICOT AND SEED

This is an improved variety of apricot, the result of selective breeding. Further improvement in the way of decreasing the size of the stone is desirable, however, and no doubt this can be brought about by careful selection, with or without crossing.

tropical climate prevails even at relatively high latitudes. There are extensive areas of the Middle and Eastern States, well toward the north, where the apricot tree may be grown without difficulty, but where no fruit can be produced because the blossoms are invariably blasted by the frosts and rains that are sure to come after they are put forth.

It is obvious, then, that this fruit presents a very specific and unusual problem for the plant developer.

In case of many other fruits, to be sure, it is desirable to increase hardiness; but with no other fruit that we have hitherto considered is it so preeminently desirable to focus on this single object. For in the case of no other is there so striking a disparity between the roots and the blossoms as regards the climate to which they are adapted.

Making the Apricot Hardy

The idea that naturally suggests itself to the plant developer is that of selective breeding, in which the individuals chosen are those that have shown themselves relatively able to withstand cold and much moisture.

These, of course, can readily be selected in any region along the outer limits of the apricot's pres-

ent zone of productivity, by merely noting the exceptional individuals that produce fruit in the season when their fellows are rendered infertile by the frost or other causes.

Seedlings grown from these relatively hardy plants would, on the average, tend to manifest exceptional hardiness; and by successive selection through many generations it would thus be possible, without any question, to modify the sensitiveness of the apricot in such a way as to adapt it for cultivation far beyond the limits of its present range.

Of course such selective breeding would be subject to the usual difficulties and complications that attend the development of any new or exceptional quality in any orchard fruit.

Here, as elsewhere, there are complications due to the fact that the fruit will not grow true to type from seed. In this regard, however, the case of the apricot is somewhat more favorable than that of most other orchard fruits, because this species has been less widely cultivated, and is therefore less complex as to its hereditary tendencies than most others.

Moreover, it is fairly easy in the case of the apricot to predict the qualities of the fruit from observation of the very young seedlings. In general the buds and leaves and wood in the first

season give one a fairly good idea as to what size and quality of fruit the future tree will bear.

On the other hand, the apricot has a peculiar habit of sending out a young shoot, and then postponing further growth until the buds set and ripen, and this complication may make the choosing of the seedlings a more difficult matter than it is in the case of apples, pears, and peaches. For when the growth is checked in this manner the buds may become turgid and the leaves of unusual size on some plants, suggesting great possibilities, whereas, in fact, these plants may have no greater intrinsic merit than others that have continued their growth and so will show at the moment smaller buds and leaves.

These complications must be very carefully taken into account in choosing seedlings to save for the development of improved varieties.

The general rule that large leaves, full buds, and large short-jointed stems indicate individuals that will bear large fruit of fine quality must be constantly regarded, but the complications introduced by the anomalous habit of growth just referred to must not be overlooked.

Can the Microscopist Help?

In carrying out a series of selections with the idea of developing a race of apricots

with blossoms resistant to moisture, there is unfortunately little to be expected from crossing different varieties of this species, because all existing varieties have always been cultivated under more or less the same dry, warm conditions.

Indeed, the outlying forms to which one would naturally appeal are chiefly natives of Asia Minor, Palestine, and Persia, and while they might serve a useful purpose, if hybridized with races now growing in America, in giving a tendency to variability and perhaps also an added virility, it is hardly to be expected that they bear hereditary factors that would greatly aid in the particular matter under consideration, because of the warm climate to which they and their ancestors have been habituated.

Nevertheless, the experiment is well worth making for we know that there are latent qualities in the germ plasm of almost every race of plants that are revealed only through hybridization, and the presence of which would otherwise be quite unsuspected.

In any event there are differences to be observed between individual apricot trees as to the relative hardiness of their blossoms. So material is at hand, with or without hybridization, from which to begin the work of selection.

Doubtless this work might be carried forward much more rapidly if we had a clearer knowledge as to what the precise anatomical conditions are that are associated with extreme sensitiveness of the blossoms.

We know that some blossoms (those of certain Japanese plums, for example) may retain their fertility even when subjected to freezing temperature; being able to live even through snow storms, in contrast to the apricot blossoms which fall under influence of the lightest frost.

But no elaborate studies have been made to determine whether this difference is associated with anatomical differences of structure, the knowledge of which might guide the plant developer.

That such differences really exist is suggested by the observed fact that the leaves of very hardy varieties of apples, for example those grown in Siberia, have exceptionally deep layers of epidermal cells to give protection to the less hardy cells that make up the bulk of the leaf. Possibly some similar modification of the cells may account for the resistant quality of blossoms that are observed to be able to withstand frost.

The Microscope May Help

If such is really the case, the microscopist might come to the aid of the practical fruit

THE APRICOT

The apricot is a very luscious fruit, and one that is highly prized. The great difficulty in growing it is that it is not as hardy as most fruits. I have experimented in the development of varieties of apricots adapted for colder climates. There is opportunity for excellent work in this direction on the part of other plant developers. The fruit developer must consider many things in producing a new variety. In the case of the apricot, evenness of size and drying quality are essential. The boxes of dried apricots here shown illustrate the attractiveness of a fruit in a perfected variety of almost ideal quality.

grower, pointing out to him the particular trees in his orchard that tend to produce flowers having their structure thus favorably modified.

This method of selection would have obvious advantages over the method of planting trees at random in the colder regions, and waiting the selective influence of frost.

If the fruit grower could gain such information as this in advance, thus selecting only the hardier individuals and subsequently making selection of the best among these, he might obviously hope to advance with greater rapidity. And as the task at best is a tedious one, the plant developer should welcome any aid that may be offered, from whatever source.

As yet, however, we have no assurance that definite assistance can be given us by the microscopists. It may be that the physical conditions that determine hardiness or sensitiveness in the flower are dependent on molecular arrangements that lie far beyond the limits of microscopic vision.

In that case, we shall be obliged to depend upon the common method of selection, picking out plants that have proved somewhat hardier than their fellows, and being on the alert at all stages to discover the correlations as to color or form of stem or leaf that are associated with

hardiness of blossom, that these may aid us in making early selection among our seedlings.

Seeking Aid from the Plum

I have said that the plant experimenter who attempts to give us a race of apricots with resistant blossoms can perhaps expect little aid from crossing the existing varieties of apricot.

Fortunately, however, there are possibilities of wider hybridizations that give far greater promise.

There are varieties of Japanese plums that will stand hard freezing every morning from the time the buds start until the fruit is of good size. With ordinary plums such freezing absolutely prohibits the development of fruit, and the apricot, as a rule, cannot withstand even a single light frost.

The resistant quality of some of the Japanese plums, then, marks it as a plant having in preeminent measure the precise quality that the apricot most conspicuously lacks.

So the question arose as to whether it may not be possible to hybridize the apricot and the Japanese plum and by so doing breed into the apricot strain the quality of hardiness, just as we have seen specific qualities bred into other plants by similar hybridization.

Fortunately it is barely possible to make such a cross. Reference has already been made to the new fruit called the Plumcot that I produced a good many years ago by making use of this particular combination. A full account of the methods involved and the difficulties overcome in producing this very unusual hybrid will be given in a subsequent chapter.

It will then appear that the Plumcot is to all intents and purposes a new species of fruit.

It combines the qualities of the plum and the apricot, but in itself it is neither plum nor apricot.

So while the plumcot has exceptional qualities of its own, it does not solve the particular problem with which we are at the moment concerned We are seeking, not a new fruit, but an apricot having a particular quality that the present apricot lacks.

And the question of the moment is whether there is a probability that after blending the strains of the Japanese plum with its hardy blossoms and the apricot with its peculiar qualities of fruit, it may be possible in subsequent generations to reassemble the qualities in such a way that we would have an apricot retaining all the fruit qualities of its apricot ancestor, but combin-

A BUNCH OF THE COMMON LOQUATS

The loquat is indigenous to Japan. The specimens here shown are very much enlarged through selective cultivation. The better varieties of loquats may be grafted advantageously on quince stock. The plant is not hardy enough, unfortunately, to be grown in our northeastern States.

ing with them the hardiness of blossom of its plum ancestor.

Were the plum and the apricot a little less distantly related the question would admit of a ready answer.

It would then be almost certain that we could, by a series of selective breedings, produce the desired combination from union of the materials at hand. But the plum and the apricot, as the qualities of the hybrid plumcot show, lie so far apart that their progeny tends to reveal a blending of characters rather than a segregation of unit characters. So it is somewhat less certain than it otherwise would be that the unit characters of the two fruits may be segregated and reassembled in the way desired.

Nevertheless, I am disposed to think that this result may prove attainable. There are great variations between the different plumcots. Some of them tend to vary in the direction of the apricot, and others in the direction of the plum. By breeding with reference to a particular set of qualities—in this case the restoration of the apricot qualities and the retention of the hardy quality of plum bloom—it would probably prove possible to segregate and reassemble the qualities now blended in the plumcot in such a way as to give us a true apricot. Enough has

already been done to convince me that this is possible.

Such being the case there seems to be no reason to doubt that by careful attention to the question of hardiness of bloom at all stages of the experiment our redeveloped apricot might be induced to retain this quality, a heritage from its Japanese plum ancestor, while retaining also the peculiar qualities of flesh and texture and flavor that are the hall marks of the apricot.

We shall have occasion, perhaps, to revert to this aspect of the subject more in detail in discussing the plumcot with regard to its various possibilities of improvement. Here it is enough to call attention to the fact that the hybridization of the apricot with the plum offers at least a possible solution of the vitally important problem of the development of a cosmopolitan apricot.

Perhaps there is no single problem of orchard fruit development that offers possibilities of greater economic importance.

Mating with Oriental Species

As to other hybridizations, we may add that there is a quite different species of apricot growing in Japan, known as *Prunus Mume,* which may possibly be of value in the development of

new races of apricots, either with reference to the essential quality of hardiness or to the development of other qualities.

This Japanese apricot bears a small fruit of very poor and acid quality, of use only for cooking. Moreover, it is not an abundant bearer, and it has few qualities that tend to commend it. It crosses readily with the cultivated apricot, however, and although the fruit is very inferior, there is always a possibility that later generations of such a progeny may develop unexpected qualities.

Even better results might possibly be attained by crossing our best apricots with the hardy Russian apricots, which will bear fruit in much colder climates, but the fruit of which is but little superior to that of the Japanese apricot, *Prunus Mume,* just described.

The Mennonites have brought many varieties of this species to America, and some of them are classed in the Eastern States as good. The best of them, however, could never be compared in size or quality with our improved Persian varieties.

There is also a fruit known as the black apricot, classified by some botanists as *Prunus dasycarpa,* which is allied to the apricot and which crosses readily with it, although it may more

IMPROVED LOQUATS

Although the loquat produces this relatively enormous seed, there is a great variation in different seedlings, some of which are almost seedless. This fact is encouraging as suggesting that it will be possible to produce a race of seedless loquats of good quality.

properly be regarded as a plum; being in fact a variety of *Prunus cerasifera,* as has been abundantly proved by numerous seedlings and hybrids produced on my own grounds.

Hybrids of this fruit with the apricot and with the Japanese apricot and Japanese plum have been made in various combinations. Here, again, I shall have occasion to go more into detail in another chapter. I mention these various hybrids here to illustrate further the possibilities of development of new races of apricots, or of altogether new fruits, through various combinations in which the apricot is one parent.

To mention only one other quality of the present apricot that is in great need of improvement, we may note that the fruit usually grows lopsided and has a tendency to ripen on one side while the other is partly green. There is great call among apricot growers, and especially from canning establishments, for a large, globular, sweet, freestone apricot with a small pit. No apricot now known fully fills the bill.

There is also opportunity to improve greatly the drying qualities of the apricot.

All these matters will, of course, receive attention from the plant experimenter who endeavors to improve this fruit at the same time that he is

considering the question of hardiness of blossom, although the latter quality deserves preeminent attention.

Fitting the Apricot to New Climates

The apricot, both as a canned and as a dried product, is becoming better known and more highly appreciated year by year. If a variety could be produced that would grow in wider territories, unimpaired by the vicissitudes of climate of our North-Central States, this fruit would probably become as important as the apple and be quite as extensively grown. And enough has already been accomplished to justify us in asserting that the prospects of extending the culture of this fruit into territories that are now prohibited is extremely good.

Already there is a variety of medium size called the Royal that grows in many regions where other apricots refuse to produce fruit, and there are a few other varieties that somewhat approach it. These offer special material for further selection, and by combining such selection with skillful hybridizing the plant experimenter should be able to produce an apricot that will stand quite unrivaled among all the stone fruits.

What the Loquat Offers

There is another fruit to which reference may be made here perhaps as well as elsewhere. This is the loquat, a plant classified by the botanists as *Eriobotrya japonica.*

There are several species sometimes classed as loquats, but the common Japanese loquat is the only one which the botanist places in the genus just named. It is a small, broad-leaved, woolly-branched evergreen, useful not only for ornamental purposes, but for its fruit which ripens from February to June, growing from blossoms that usually appear in December and January.

The wild loquat of Japan bears a small fruit about the size of a very large cherry or small plum, nearly all skin and seeds, and outwardly somewhat resembling a small apple or large hawthorn fruit, except that it is yellowish in color and rusty woolly.

But there are several improved varieties of this fruit, due to selective cultivation. These oftenest bear pear-shaped fruit that is sometimes two and one-half inches in length and two inches in diameter. The increased size is due to the pulp, the seeds not being changed in size.

IMPROVED LOQUATS

The loquat is a fruit that has become popular only in comparatively recent years. In its unimproved varieties it is not very attractive, as the stone occupies a large part of the fruit, the pulp being not only relatively primitive in quantity but of no very great degree of succulence. We greatly increased the size of the fruit, and have also increased the relative size of the pulp, although the stone still is larger than might be wished. The loquat is still in active training.

Indeed there is a tendency in the direction of smaller seeds, and some of the improved loquats are almost or quite seedless.

I know of one tree that generally bears fruit that is altogther seedless. This would be a very valuable tree were it not that this particular variety is extremely unproductive.

The fruit is usually of a pale yellow or deeper golden color, sometimes shaded with orange and crimson on the sunny side. The flavor suggests that of some early apples, and is generally considered a superior fruit. The fruit grows in clusters of three to ten or more, and the improved varieties bear very abundantly. In some cases two crops may be produced in the same year.

The tree grows in the Gulf States and along the Pacific Coast, and it is considerably hardier than the orange, but not quite as hardy as the fig. It is quite commonly grown in California and similar climates for the decoration of parks and home grounds, but most varieties grown for this purpose bear little or no fruit. It grows readily from seed, which germinates at any time of the year. But it is a very difficult seedling to transplant, so the seeds should be planted in pots and the entire contents turned out when the plant is a few inches high, after the method

used with geraniums and various other garden plants.

The better varieties of loquat can be grafted during January and February, or budded in June, July, or August, on seedling loquats or quince.

Grafting may be done by the "cleft" method or any other of the usual methods already described. It is well to remove most of the leaves from the cion, leaving a cluster of the tip bud leaves. Wax should be applied freely, and a paper sack tied tightly over the graft and stock to protect it from drying winds. Later the sack may be partially opened, and at last removed.

The large number of seedling loquats in my orchard were grown from one tree, bearing giant fruit, imported from Japan. Seedlings fruited at about the age of three years from seed, some not until the fourth year.

The better varieties of the loquat are quite often grafted or budded on common quince stock, on which the trees thrive as well apparently, as if on their own roots. This would indicate the possibility (but not necessarily the probability) of crossing the loquat and the quince.

So far as my experience indicates, the loquat is perfectly self-fertile. It is readily crossed and

yields rather promptly to efforts at its improvement. There is every probability that it will become a much more important fruit in the near future. And among our minor orchard fruits there are few, if any, that offer better opportunities for the plant experimenter.

There is no single problem of orchard fruit development that offers possibilities of greater im--portance than the development of a cosmopolitan apricot.

CITRUS AND OTHER FRUITS FROM THE TROPICS

New Experiments Well Worth Trying

I AM sometimes asked why I did not establish my experimental gardens in southern California.

My answer is that I chose the location because irrigation was not necessary in this part of the State and for its equable climate and fertile soil, but that I soon found good reasons for not changing it.

The chief of these is that I desired to produce fruits, flowers, and vegetables adapted for growth in the widest possible territories, and it was therefore desirable that I should be located in a region where the plants could have a test of moist, cool winters during the time of their development. Moreover, nearly all our orchard fruits thrive and come to perfection in this part of the State better than almost anywhere in the southern part.

But, on the other hand, the location has not been altogether without its drawbacks; for where-

as I am able to experiment to better advantage with most plants, I am somewhat handicapped in the attempt to deal with a few of the more tender ones.

This is notably true of the orange and its allies of the citrus family.

These fruits very naturally interested me from the outset, not only because of their economic importance, but because the five familiar species of the family, namely the orange, lemon, lime, grape fruit, and citron present inviting diversities of form and habit, and yet are so closely allied that they cross very readily, and thus give the plant experimenter precisely the opportunity that he is always seeking.

It is probable that all these citrus fruits sprang from one original species growing somewhere in the region of northern India, though a primitive form was described by Dr. Livingstone in central Africa, but probably not a native there.

But although the habitat of these plants has always been restricted to subtropical climates, yet they have become so diversified as to form fairly good species, and the different traits of the various members of the clan are fairly fixed. Not that any of them may be raised advantageously from seed, for here they show the same diversity that is shown by the other cultivated

fruits. But all varieties of oranges, for example, differ quite radically from any variety of lemons, and the seeds of the orange will not produce the lemon, or vice versa, however widely the progeny may differ from the parent form within the limits of specific variation.

Attempts to Produce a Hardy Orange

My attempts to cultivate the citrus fruits date back about a third of a century.

I pursued the investigation actively for a time, securing everything that was to be had, including the small Japanese variety called the Kumquat, or Kinkan, *Citrus japonica.* This is a small, limelike fruit produced in amazing abundance, having acid flesh but a skin with sweet, pleasant, orange flavor.

Wild, though not always native oranges were sent me also from central Africa, Australia, and South America, and the best cultivated varieties from Burmah, Ceylon, and various less distant regions.

The object primarily in view was the production of a hardy orange; one that would grow in northern California, and in regions of the eastern United States well to the north of the present limits of growth of this tender fruit.

FRUIT OF THE GUAVA

The Guava is a subtropical fruit that has only recently been given attention in California and in the Southern States. It is chiefly known in temperate climates as the producer of a very admirable jelly of unusual piquancy and unique quality. Very little has been done hitherto in the way of improving the fruit, but now that it is claiming the attention of the plant developer, it will doubtless be greatly modified. Unfortunately it is too tender to be grown anywhere in the United States except along the Pacific Coast and about the Gulf.

My experiments were promising at the outset, and I soon had a variety of hybrid seedlings.

But there came a series of cold winters that destroyed the entire citrus orchard, and after one or two other tentative efforts, I was compelled to admit that my farms are located in a region unsuited for development of the citrus fruits. The initial investigations through which the hardy orange is developed must be made in a more favorable locality.

I frequently mentioned my belief that a hardy orange could be developed, however, and it is satisfactory to record that experiments along this line have more recently been undertaken under the patronage of the United States Government.

The variety known as *Citrus trifoliata,* a wild form which had never been much cultivated in America, was known to be exceptionally hardy This was hybridized with the sweet orange in the Government experiments just referred to, and the early results were thought to be rather promising.

"Among the seedlings observed," says Professor E. M. East, "several have proven valuable. They form a new class of citrus fruits and have been called *Citranges.* Three of these varieties have been named the Rusk, the Willits, and the

Morton. The Rusk, which is a bybrid of orange crossed by *trifoliata,* is a small fruit with a bitter tang like the pomelo, with a turpentine flavor. It is said to make excellent marmalade and preserves. The Willits, coming from a cross of orange upon *trifoliata,* is a rough, but thin-skinned fruit, resembling an orange in appearance but a lemon in flavor. It is used as a condiment or for citrangeade. The Morton, coming from the same kind of cross as the Willits, is a large, juicy, almost seedless fruit, only slightly more bitter than the sweet orange. It has been remarked that instead of an orange the experimenters were handed a lemon.

"Young trees of these three varieties have endured a temperature of eight degrees above zero, and it is thought that by the use of these, and of similarly obtained varieties, citrus fruit culture can be extended fully 400 miles north of the present region."

Doubtless the orange will always remain a relatively tender fruit, for it is an evergreen that has never wandered far from the tropics. But it is equally little to be doubted that it could be made much hardier than any existing race of citrus fruits, and the incentive for the production of such a hardy race is so great that there should be no dearth of experimenters in the field, even

though this will be too expensive except by Government or other combined aid.

The orange crop is occasionally blasted even in Florida by unusual frosts. In 1895, for example, the loss of the trees themselves was so great as to put a serious handicap on the industry for a term of years. So it is imperative that a race of oranges should be developed that will be capable of at least enduring occasional periods of cold. But, aside from the tentative experiments just noted, very little has hitherto been accomplished in this direction.

The field is open for any experimenter who has a large capital to work with and is located in a region that lies well within the present orange belt (preferably near its northern limits) and the reward that awaits the successful developer of a really good hardy orange is sure and significant.

Seedless Citrus Fruits

Everyone is familiar nowadays with the so-called Navel Orange, which combines the very notable quality of seedlessness with large size and general excellence of quality.

The seedless condition of this orange is not the result of skillful selection, but appeared as a "sport" in certain wild oranges of Brazil. There

are almost numberless varieties of oranges now growing in the region of the Amazon. A lady who was traveling through South America was surprised to find among the oranges served at the hotel where she was stopping some that were seedless—a thing hitherto never conceived even as a possibility among cultivators of the fruit.

The discovery was communicated to the Agricultural Department at Washington, and in 1870 the new variety was imported.

Four years later specimens of the tree were sent from Washington to California and the fruit, which was subsequently christened the Washington Navel in recognition of its introduction and its peculiar form, soon came to be extensively cultivated. This variety, like most of the citrus fruits, is subject to bud variation and a number of more or less distinct varieties have made their appearance. But there is still abundant opportunity for improvement through further selection.

Cultivation of the Orange

The orange is budded or grafted on roots of its own species or on those of the lemon or the shaddock, better known in its improved forms as the grapefruit.

The process of budding is altogether similar to the budding of other trees and it presents no difficulties. Stocks may be grown from seed but, as already noted, seedlings cannot be depended upon to reproduce the parent forms, and all the best varieties of orange are propagated by grafting.

The chief peculiarity of orange culture is that it is necessary to grow the fruit on irrigated soil.

Water is, of course, essential to all plant life, but a tree like the orange, with heavy evergreen foliage, makes exceptional demands, and it is imperative, if the large, juicy fruit is to be brought to perfection, that these demands shall be adequately met. It also requires a high summer temperature.

It was the recognition of these facts by the old Moors more than a thousand years ago that made Valencia in Spain, thanks to the Moorish system of irrigation, the heart and center of the orange industry of the world. The irrigation system established by the Moors is still in successful operation, and Valencia remains the largest single shipping port for oranges anywhere in the world.

It is only in very recent years that California fruit has challenged the product of the Spanish orchards.

The absorption of water by the roots of the tree, and its elevation through the trunk to supply the deficit made by constant transpiration from the pores of the leaves is a phenomenon that has been perfectly familiar to botanists for a long time. It was demonstrated experimentally by Stephen Hales early in the eighteenth century. But the forces that lie back of the phenomenon have been very little understood.

Very recently one of the most celebrated American botanists has declared that the cause of the rise of sap in trees remains perhaps the most interesting of botanical puzzles.

It is, in effect, as some one has pointed out, a case of water running up hill, and many botanists have found it mystifying that the plant tissues are able to withstand the pressure that a column of water must exert, particularly in the case of tall trees.

The Rise of Sap in the Tree

In fact, however, it should be recalled that the sap in the tree is not carried in open tubes comparable to the arteries of the animal system.

If it were in such tubes, doubtless no plant tissues could withstand the pressure that would be exerted by the weight of the column of water, carried, let us say, to the top of a redwood tree.

For that matter, a column of water in even a relatively small tree like the orange would probably exert a deleterious pressure on the cellular structures.

But in reality the water in the plant is contained largely in the cells of the plant tissue, and is passed on by osmosis or exudation from one cell to another.

It seems probable that the laws of osmosis as developed by the Dutch physicist Vant Hoff, partly in response to questions raised by Professor de Vries, give a clew to the entire subject of the rise of sap in the tree.

According to Vant Hoff's theory, osmosis or the passage of water through a membrane from a weaker to a stronger solution, is due to the pressure of the molecules in the stronger solution which, in virtue of their greater numbers, beat against the cell wall and exert a pressure exactly comparable to the pressure of a gas. The push of the molecules against the cell wall suffices to squeeze water through the wall until there is an equalization of pressure on both sides.

As the cell sap in the cells of the rootlets of a plant is more concentrated than the watery solutions in the soil about it, osmotic action is established, which results in the cells taking up a certain amount of water. But cells that thus

take in water at once give up a portion of it to their neighbor cells, and these in succession pass it on to their neighbors. Thus, through an endless series of reactions between the cells the sap is carried up in the living wood next to the bark of the tree and ultimately to the leaves.

Nature's Bucket Brigade

The process is not altogether unlike the activities of a fire brigade in the rural districts, where a line of men is formed from the fire to the nearest well, and buckets are passed from hand to hand.

If the fire is in the upper story of a building, men on the ladder may similarly hoist one bucket after another from hand to hand. And in this case it is obvious that there is no question of a column of water to exert pressure. The water is transported in individual buckets each one independent of the others.

And it would appear that the case of the water in the plant cells is closely comparable. Each pair of cells constitutes a system more or less independent of all the others.

The forces of osmosis, operating between each pair of cells, are in command of the situation and so break the continuity that all semblance to a continuous column of water is lost.

The full power of the molecular forces that, acting jointly, carry the water to the tree tops will best be understood when it is recalled that if a rubber tube is put tightly about the end of an amputated twig, water in this tube will be forced upward by the pressure of water in the cells of the twig. This experiment, first made by Hales in 1727, in itself shows how utterly different are the conditions of water in the tree from the mere mechanical condition of pressure that governs the water in a closed tube, or otherwise standing in a single receptacle.

Titanic Molecular Forces

Many boys have made the experiment of bursting a barrel by the pressure of water in a small iron pipe projecting upward from the barrel.

Whoever has seen the experiment will not doubt that the physical laws governing the water in the trunk of the tree are quite different from those that govern the water in the iron tube. And the difference is due, the physicists assure us, to the interposition of the molecular forces.

Whether or not the laws of osmosis, above outlined, as discovered by Vant Hoff, give full explanation is matter for the physicists to decide. As yet they are not quite sure about it. But that

SWEET LEMONS

To speak of a sweet lemon seems a contradiction of terms. Nevertheless there are varieties of lemon that are distinctly sweet. The one here shown has the peculiarity that the skin peels off readily, like that of an orange. The tree on which it grew will be utilized for further experiments in selective breeding.

the osmotic forces are at least partly instrumental in lifting the water, all are agreed.

Meantime, referring specifically to the orange, it requires no great powers of observation to discover why this tree stands in such preeminent need of an exceptional water supply.

It is only necessary to recall that the bulk of the fruit is juice, each orange containing four or five ounces of water, to discover what the tree does with the liquid it imbibes so freely. A well-laden orange tree, with say a thousand mature fruits, is carrying the equivalent of thirty or forty gallons of water in its globular buckets; and of course there is constant transpiration of moisture from the leaves which in the aggregate is far greater.

Hybridizing Possibilities

And all of this, of course, applies not merely to the orange but to the allied citrus fruits, in particular to the grapefruit and the lemon.

Indeed, the entire company of citrus fruits is characterized by exceeding juiciness of pulp, the bulk of the fruit being made up of water—with delicious acids and sweets contained therein—merely intermeshed with enough thin fibrous tissues to give stability to the fruit structure.

These fruits are further characterized by the unique quality of the fruit covering, which is

painted with marvelous hues that are so unique as to have given their names to prominent pigments of the painter's color box; and incorporate curious series of minute oil wells laden with essential essences of no less individual quality.

These traits, among others, mark the citrus fruits as constituting a highly specialized and isolated group of plants.

It is not to be expected that any one of them could be hybridized with a member of any other family. But, on the other hand, within the bounds of the citrus family there is full opportunity, as I have already pointed out, for cross-fertilization.

Many interesting developments would have resulted from the hybridization of oranges, lemons, limes, and citrons in my orchard had not the frost treated the tenderlings so harshly. Not unlikely there would have been developed new citrus fruits differing from any existing one as markedly as the plumcot differs from apricot and plum. This, of course, is only matter of conjecture, for the experiments were cut short, as already told, before they passed beyond the early stages.

Still the fact that I was able to effect hybridization between the various citrus fruits is highly suggestive and should prove stimulative to other workers.

Here is a field as yet scarcely entered and one that offers almost unbounded possibilities. The orange industry is the great fruit industry of California to-day, as it is of the Gulf States. In both of these regions experimenters should take up the work. It is at least possible that new and strange citrus fruits may thus be brought into being.

As a single hint suggestive of possibilities, let me recall that the very *earliest* plum in existence to-day is probably the one that I developed by successive hybridizations which ultimately introduced and blended the strains of six species including some of the latest plums.

Possibly, then, the problem of developing an orange resistant to cold—one that may be grown not merely along the Gulf but along the Great Lakes as well—may be solved in similar fashion. It seems paradoxical to suggest that the blending of oranges from a half a dozen tropical and subtropical climates—India, Arabia, northern Africa, Brazil, Florida, southern California—might produce a fruit adapted to the climate of, let us say, Missouri or Ohio; yet the case of my early plum, descended from late ancestors, suggests that this idea is not altogether chimerical. This work will be greatly simplified by the fact that we now have an orange

which, though inferior, without special selection for this purpose, is hardy as far north as Philadelphia.

Other Subtropical Fruits

And a similar suggestion may be made regarding a considerable company of other fruits that have come to us from tropical and subtropical regions.

The olive, the fig, the persimmon, the guava, the alligator pear, the banana, the pomegranate, the pineapple—these are but a few of the more familiar members of a varied company of fruits, not in themselves related except that they all had their original home in the tropics and for the most part have proved indisposed to migrate extensively into temperate zones.

One or two of these, to be sure, have shown a tendency to follow the example set by the plum, the pear, and the apple, and try their fortunes in regions lacking the perpetual summer of their original habitat.

Most notable among these, perhaps, is the persimmon, which made its way to Japan on one continent, and to the south central regions of the United States on the other.

This fruit has been cultivated to best advantage in Japan, where the secret was first discov-

ered that its astringency is lost when the fruit is packed closely in air-tight receptacles.

It appears that carbonic acid in the absence of oxygen produces in the fruit precisely the chemical changes necessary to transform it from an astringent and inedible fruit to a highly palatable one.

I have raised vast numbers of seedlings of the Japanese persimmon and have attempted to produce new varieties by crossing this with the American persimmon; but as yet I have not succeeded in effecting this hybridization—chiefly, perhaps, because the American species is such a shy bearer here that I have had few good opportunities to cross-fertilize the two.

Now that the good qualities of the persimmon are beginning to be more generally recognized, further experiments in this direction will probably be carried out, and there is every reason to expect that new and greatly improved races of persimmons may thus be developed.

Whoever will contrast the hybrid Japanese-American plum of to-day as developed in my orchards at Santa Rosa and Sebastopol with the best plums of thirty years ago will see at least a suggestion of new possibilities in the prospective union of the Japanese and American persimmon. For the best existing varieties of persimmon—

the Japanese races are incomparably superior to the American—have such qualities as furnish a secure foundation on which to develop a really notable orchard fruit.

Fig and Mulberry

Another series of experiments that I have carried on, as yet unsuccessful, with subtropical fruits, is the hybridization of the fig and the mulberry.

The fig, as is well known, grows abundantly in California. Nearly everyone has learned that for many years after it was introduced the fig was a very poor bearer, blossoming abundantly, but failing to ripen satisfactory fruit. The trouble, as was presently discovered, was that the peculiar minute species of wasp, which is the sole bearer of pollen from the male or so-called Capri fig to the pistillate flowers, was not found in California. So soon as this insect was imported from Italy, figs of good quality were borne in abundance by hitherto barren trees.

The fig has been under cultivation perhaps as long as any other fruit, and it is exceedingly variable when grown from seed.

I have grown seedlings in abundance, but 99 out of 100 of them produced worthless fruit, at least when quite young.

You plant seeds of the white fig and you are almost as likely to get black or brown figs as white ones.

This is probably because the Capri fig has never been cultivated for color; in fact very little attention has ever been given to it, even for the development of vigor and productivity.

About the only attention paid it by the fruit grower has had reference to the early or late time of blooming. This is important merely because it is necessary that staminate and pistillate plants should bloom at the same time, else the fig wasp obviously cannot perform its pollenizing service

A pound of European figs, grown from flowers fertilized by the Capri insect (otherwise the seeds would be infertile) will produce perhaps ten thousand seedlings. But it requires patience to wait fifteen or twenty years to test the fruit, and it cannot be fairly tested in less time.

It is difficult to hasten the process by grafting because the fig cion does not take kindly to being so transplanted.

Doubtless a satisfactory method of grafting might be developed, however, were sufficient attention given to the subject. Perhaps nothing more would be necessary than to protect the cion carefully against drying, by covering it with a paper bag until union has taken place, as is

SEEDLING POMEGRANATE FRUITS

This picture shows the characteristic shades and color of the pomegranate, and suggests the wide variation in size of the different fruits. It is said that there are several varieties grown in Bengal, one being seedless, and another growing, it is alleged, to the size of the ordinary human head. This report may be taken with a certain allowance, but it suggests possibilities of development of the fruit through selective breeding that have as yet not been realized in this country. The fruit is worthy of more attention than has hitherto been given it by horticulturists.

done in grafting the orange and various other fruits, and the walnut.

As just stated, the attempts to hybridize the fig with its relative, the mulberry, have not proved successful.

But this was probably because I could not give enough time and patient attention to the effort. The two fruits are botanically related and I sometimes think of the fig as a mulberry turned outside in. In Mexico there grows a fig halfway between the two genera that is a flat coin-shaped fig with the flowers exposed on one side.

It should be possible to effect hybridization between the two species, and perhaps greatly to improve one or both of them; even to develop a wholly new fruit through this union—like the plumcot.

Moving Tropical Fruits Northward

We need not enter into further details in connection with the subject of tropical fruits because I am chiefly concerned in this narrative to tell what I have accomplished in the way of plant development rather than to dwell on unrealized possibilities. But I cannot refrain from urging upon others, who are geographically so located as to bring the tender fruits within the range of their experiments, the desirability of undertak-

ing extensive series of investigations in this practically untrodden field.

It should be recalled that all of our fruits, even the hardiest ones that now grow nearly to the Arctic zone, must have come originally from the tropics, or at least from the milder climates.

The fact that the plum, pear, and apple have become hardy enough to resist winters of almost arctic severity is in itself all-sufficient evidence of the adaptability of the fruit bearers, and should be an aspiring object lesson to the experimenter with fruits that still retain the tropical and subtropical habit.

It requires no very great powers of prophetic vision to forecast a day when a large number of fruits that now are known only in subtropical zones will have made their way, under guidance of the plant developer, across many degrees of latitude that at present seem like impassable barriers.

The Feijoa (pronounced fay-zho-a) or fig guava (*Feijoa Sellowiana*) from Brazil, a vigorous fruiting shrub; the Cherimoya (*Annona Cherimolia*) from the Central American highlands, which has been classed with the pineapple and the mangosteen as making up the trio of the world's finest fruits; the Australian Macadamia (*Macadamia ternifolia*), prized for both

fruit and nut; the Natal Plum (*Carissa grandiflora*) from South Africa, with its fragrant flowers and scarlet fruit; and the White Sapote (*Casimiroa edulis*) from Mexico with quincelike fruit of unique flavor—these are among some of the tropical and subtropical products that have come to us within recent years and that promise to make secure place for themselves among well-prized fruits of orchard and market. And there are others yet to come.

Meantime I should not like to predict as to which among the fruits that now are confined solely to the region of the Gulf of Mexico and to California as their northern limits, may not within a century be growing and bearing luxuriantly in the region of the Great Lakes.

It should be recalled that almost all of our fruits, even the hardiest ones that now penetrate nearly to the Arctic zone, must have come originally from warmer climates.

HOW THE PLUM FOLLOWED THE POTATO

Our First Work in California

WHAT you need is a complete rest and a change of climate. Go to California for the winter.

This, or something like this, I am told, is a very common prescription of the New York specialist, or for that matter, of physicians everywhere.

The value of rest is almost axiomatic, and the benefit to be derived from a change of climate is matter of familiar observation to layman and physician alike.

Now I have more than once called attention to the similarity between human beings and plants as to many of their hereditary characters and environmental responses. And the present case furnishes another illustration in point.

Rest and change of climate are no less beneficial to the plant than to the human patient.

And as new surroundings arouse the mind and give a fresh stimulus to the imagination, in the case of human beings both individually and collectively, so the transplantation of a plant to new soil sometimes brings out unsuspected racial tendencies and stimulates variation in such a way as greatly to improve individual specimens and quite to transform their progeny.

I had seen instances of this as applied to many different species of plants from the time of my first coming to California. I myself felt the mental uplift of new surroundings, and seemed to find evidence that plants that had come from the eastern United States, even as I had come, were not unmindful of a similar influence.

No species of plant or bird or animal is quite the same on the Atlantic and the Pacific seaboard. We have but to compare specimens of such familiar birds as the robin, quail, and meadow lark, or of plants of any garden variety to note the evidence of beginning transformations.

My early letters from California told of my astonishment in seeing "great rose trees, thirty feet high; veronica *trees,* and geranium *trees.*"

Of course in those cases where the species has been long resident in California the change has progressed so far that representatives of what

were once members of the same clan no longer are to be classified as of the same species.

All of this was observed from the outset, just as many another man had observed it. Indeed these things are too patent to escape notice. But, unlike many others, I was impelled to inquire whether some useful application might not be made of the observed influence of the California climate on immigrant plants.

The Prescription Applied to Plants

In following up this idea I was led to apply to a vast coterie of plants the prescription which has become so popular with the present-day physician in the treatment of his patients.

"Take a rest, and find a complete change of climate. Go to California—and stay there," was the modified form of the prescription as I gave it to the plants of the remotest regions of the globe to which I could send word.

And the result of the carrying out of this prescription will require some volumes in the telling For the plants that came to me in response have furnished the chief material out of which a large proportion of my developments of new fruits, grains, grasses, trees, vegetables, and flowers have grown.

THE CLIMAX PLUM

This is the Climax, a very large, early plum now exported in enormous quantities. It is the largest and best early-ripening plum known. (Nearly full size.)

Perhaps foremost in the host of immigrant plants that have had a large share in my life work must be named a little company of plum seedlings that came to me at the very beginning of the period when I was renouncing the calling of the regular nurseryman and determining to devote my entire attention to the development of new races of plants.

The capacity for development shown by this little company of seedlings was nothing less than phenomenal.

The change of climate from Japan to California was, apparently, of all things precisely what they needed if they were to put forth their best endeavors to better themselves, and in bettering themselves to confer benefits upon humanity.

Perhaps foremost in the host of immigrant little company of twelve plum seedlings that came to me with my first successful shipment in 1885 constituted, from an economic standpoint, the most important importation of fruit bearers ever made at a single time into America. For the immediate bud sisters of two of these seedlings constitute to-day varieties of plum that are recognized as standards throughout the whole world; and from the progeny of these and others were developed plums of such size

and quality as not alone to give this fruit an altogether new standing in the markets of America, but fairly to revolutionize the plum industry in such far away regions as South America, Africa, Australia, New Zealand, our own Southern States, and the States of the Pacific Coast.

Already, when scarcely more than a boy in New England, I had had the good fortune to develop a new race of potato that had proved of vast economic importance, supplanting most other varieties of its tribe in widely extended regions, and making its way triumphantly round the entire world.

Now I was enabled, practically at the outset of my work as a plant developer, to introduce races of plums that followed and even outdistanced the potato, revolutionizing a great fruit industry in widely scattered regions of two hemispheres and preparing the way for other conquests in fruit development of which even now the limits are quite unpredictable.

Visionary indeed must have been my dreams —a forecast of the possible result of this importation of the twelve little plum seedlings was more than a faint adumbration of the actual dénouement.

I recall very vividly the precise stimulus that led me a number of years before the Japanese seedlings were actually imported to turn my eyes toward Japan as the probable source of a new race of plums.

A Sailor's Yarn and What Came of It

Browsing among the books of the Mercantile Library in San Francisco, I had chanced to come upon an account of the wanderings in Japan of an American sailor, and what particularly held my attention was his mention of a red-fleshed plum of exceptional quality that he had seen and eaten in the province of Satsuma in southern Japan.

That red-fleshed plum appealed to me, and I determined to secure a specimen of it for my own orchards.

The sailor reported in his book that he had seen a single plum tree bearing this "blood plum of Satsuma." But of course the rarity of the fruit made it all the more alluring. So in due course when I came to make importations of native seeds, plants, and bulbs from Japan, I asked Mr. Isaac Bunting, an English bulb dealer in Yokohama who collected these for me, to visit the southern part of that country and

BEAUTY PLUM FRUITS

This is probably the finest plum ever produced up to the present year on this earth. It is extremely early, very large, highly colored and of the most exquisite flavor. Though introduced quite lately, it is grown and shipped in enormous quantities. (About one-half natural size.)

make a particular effort to procure with others some of the red-fleshed plums.

Mr. Bunting complied with my request, but, greatly to my disappointment, the first lot of young trees he shipped to me arrived (Nov. 5, 1884) in such condition that I despaired of doing anything with them, and I immediately sent a request for another shipment, and gave definite instructions as to packing.

A little over a year later, on Dec. 20, 1885, there arrived the twelve seedlings to which I have already referred. And this time, to my great satisfaction, the tiny trees were found in good condition.

A few days after these seedlings were received, the Gold Ridge Farm at Sebastopol was purchased, eight miles from my Santa Rosa place, and here, as soon as they were large enough, cions from these twelve little strangers were grafted on to older trees and thus brought early to maturity.

One of them bore fruit the following summer and the others in the course of one or two succeeding seasons.

And so well had the little immigrants responded to the stimulus of new suroundings that each one of them revealed, I make no doubt, the very fullest possibilities of its heritage. More

than that of course was impossible, but it may well be doubted whether any one of the company would have produced fruit quite of the same order had it been nurtured in the climate and fed from the soil to which its ancestors had been habituated.

Rest and a change of climate could not give new hereditary possibilities, but they could be instrumental in bringing dormant possibilities to full realization.

How Rest Stimulates Growth

Possibly this statement requires a further word of explanation, for I think we have not elsewhere emphasized—though the subject has been once or twice mentioned—the value of rest in enhancing the vitality of plants and in giving them new capacity for growth.

Of course nothing is more familiar—and therefore nothing seems more commonplace—than the annual dormancy of plant life in general throughout the winter season in temperate zones.

But until recently no one had particularly associated such dormancy with the vigorous growth of the reviving plants in the springtime.

It was familiarly known that tropical plants keep up their growth, even if somewhat intermittently, throughout the year; and it was

assumed that the plants of temperate zones had taken on the habit of winter rest merely because this habit was forced upon them by the exigencies of climate. And indeed, there is no reason to doubt that such was really the origin of the habit of winter rest. We have had at least one illustration, in the case of the winter rhubarb, of the readiness with which a plant resumes the habit of perennial activity.

We suggested in that connection that perennial growth is the normal and primitive habit of the plant; and there can be no occasion to modify that suggestion.

But even though the winter sleep of the plant was forced upon it, there is reason to believe that the habit thus inculcated is of great utility in conserving the energies of the plant and promoting its vital efficiency.

The experiments that justify this conclusion have been made in recent years by a number of different botanists, and they have conclusively demonstrated that it is quite the rule for a plant to develop exceptional powers of growth immediately after it comes out of a period of dormancy induced artificially.

Plants narcotized with the fumes of ether or chloroform, for example, are rendered quite incapable of growth while subjected to the fumes.

THE BLOOD PLUM
SATSUMA

This is the plum about which I read in the Mercantile Library of San Francisco many years ago. My interest was aroused and I at once sent to Japan for the plant, along with others, and subsequently utilized it to very great advantage in my plant-developing experiments. The original imported Satsuma is the parent of all the red-fleshed plums now grown in America. (Natural size.)

They are stupefied and their condition of dormancy or lack of vital activity is curiously analogous to the unconsciousness of the narcotized human subject.

But so soon as the closed case in which plant and narcotized fumes are confined is removed and the plants resume normal relations with soil and air, they take on at once a relatively prodigious and quite unprecedented capacity for growth, shooting upward at a rate that soon sends them far above their companion plants that have not been similarly put to sleep.

This obviously suggests that the rapid growth of the young shoots of herbs and trees in the springtime is probably enhanced greatly by the period of rest out of which the buds have just come. And the further corollary suggests itself that the period of rest forced upon a seedling that is, for example, dug up in Japan and shipped half way round the world may ultimately prove of benefit to the seedling, stimulating it to such growth as it would not have found possible had not the period of dormancy been forced upon it.

Freezing "Rests" Animal Tissues

An analogy from the animal world which seems to have application is furnished by the

recent experiments made at the Rockefeller Institute in New York by Doctors Montrose W. Burrows and Alexis Carrel.

In the course of their extraordinary tests in the growing of animal tissues in an artificial medium, they discovered that such tissues might retain their vitality and capacity for growth not merely when cut from the living animal but when they were taken from the tissues of an animal recently killed.

And if the body of an animal was placed in cold storage from the moment of death, the tissues were found to retain their vitality and capacity for growth for many days, instead of for an hour or so only, as would have been the case had they not been placed in cold storage.

Moreover, the growing tissues themselves, which under proper conditions could be kept alive for weeks and even months, could be placed in cold storage at a freezing temperature and kept there for days without interfering with their subsequent capacity for growth. Yet, if the slides containing these same tissues were kept for half an hour outside the incubator in a room at ordinary temperature, they would inevitably die.

In Dr. Carrel's phrase freezing seemed to "rest" the tissues and give them new powers of growth.

When we recall that vegetable protoplasm and animal protoplasm are fundamentally of the same constitution, built of the same elements and subject in large part to the same laws of growth and decay, the conclusion seems unavoidable that plant tissues also must benefit from "rest."

The application of these various experiments to the case of our seedling plums seems obvious and fairly convincing. The force of the analogy is emphasized by the reflection that the seeds of plums germinate far more rapidly after freezing. It may be recalled also that certain plants to be forced in the greenhouse in an off season will not respond well unless their roots are first frozen for a brief period. Such is the case, for example, with ordinary rhubarb.

Success at the Outset

But, of course, I would not be understood as implying that the rest gained by these little plum seedlings in the course of their long journey was the primary cause of the extraordinary vitality that they manifested.

For the full explanation of that, we must of course look to their ancestry, and we shall have occasion to make inquiry as to this in another connection.

TYPE OF SELECTED BLOOD PLUM SEEDLING

A greatly improved variety raised from a cross of the Blood Plum of Satsuma and one of my new varieties. This type is highly prized for jelly making. (*Correct size.*)

Nor need we here raise the issue as to precisely what share the new conditions of climate and soil may have had in stimulating the strangers. Let what has already been said suffice for the moment as to this, and let us examine the notable members of the company more in detail as to exceptional qualities that they presently manifested.

After all, it is more important to know just what the little seedlings achieved than to attempt to say just what share different causes had in the achievement.

In view of the very remarkable results, it should perhaps be explained that the Japanese plums are in general subject to great variation; the reason being that it has been the custom, which still prevails pretty largely, to raise the fruit from seed instead of propagating it by grafting, as is done in this country and in Europe.

So the little seedlings that came to me were doubtless of mixed heritage. In a word they had been produced by cross-fertilization between races not thoroughly fixed.

In dealing with them I profited by experiments that had been made, doubtless quite unwittingly, and with the aid only of insect pollenizers, in Japan in the preceding plant genertions.

In any event, it was demonstrated in due course that the seedlings were a very remarkable lot. Each of the twelve produced fruit of interesting character, and two of them gave a product altogether out of the ordinary.

Both of these were introduced in 1889, and met with immediate and permanent success.

The one first offered to the public bore fruit in 1886, the summer after its importation. In my year book I described this fruit as "very large, conical, heart-shaped, red with white bloom; very good."

In fact, the appearance of the plum, its size, and its delightful flavor and aroma at once proclaimed it as an exceedingly valuable acquisition.

And naturally being pleased with it I called it to the attention of a number of prominent horticulturists who visited my experiment orchard during the next two or three years. Among these visitors was Professor H. E. Van Deman, Pomologist, U. S. Department of Agriculture. Professor Van Deman was much interested in this new fruit and suggested that it should be introduced immediately.

After talking over its qualities thoroughly, he requested that upon its introduction it be given the name of "Burbank."

Accordingly in 1889 this new fruit was offered to the public as the Burbank Plum.

The Career of an Immigrant

The story of the ultimate success of this fruit will be told statistically in another connection. Suffice it here that the Burbank plum presently outranked all others as a California shipping plum, and at the present time in the east is the most popular and most generally offered for sale in the markets. Last year 125 carloads of this fruit were shipped to the eastern market from California.

Of course the career of this plum, like that of every other young fruit, has been subject to vicissitudes.

Some who have attempted to grow it in climates to which it is not adapted have considered it of small value. Yet there are few climates where it does not thrive; and for every orchardist who has tried it and found it wanting there are hundreds throughout the world who have been astonished and delighted at its value and have planted large portions of their orchard with this variety.

Although there are certain latitudes, certain conditions of humidity, and certain conditions of temperature under which it will not thrive, the

A KELSEY-SATSUMA HYBRID

The Kelsey, an original oriental plum, has also been used in hybridizing experiments. The hybrid here shown resembles the Kelsey in form, but shows the influence of the other parent in the matter of color. It is an interesting product, but was not thought worthy of introduction, as the quality was not up to my standard. (Natural size.)

Burbank has been able to adapt itself to more varied conditions than any other plum under cultivation.

By way of illustration, I may cite a letter from an extensive grower at North East, Pa., who states that his orchard of Burbank trees survived the extreme cold of the winter of 1912-1913, during which the thermometer registered as low as 30 degrees below zero, and at the usual time in the spring put forth blossoms abundantly that bore their habitual abundant crop of fruit.

Compare with this the opposite conditions of climate in some of our more southern States and in some sections of Africa where the Burbank is extensively grown—and we have a story of remarkable adaptability on the part of this plum.

The Blood Plum Satsuma

The other notable plant among the twelve seedlings was a representative of the race about which the sailor had written and about which I had read with such interest years before in a San Francisco library.

This was, in short, a plum with red flesh, something hitherto unknown among the plums of Europe or America.

Red flesh in a plum is a character so conspicuous that it is not likely to escape attention even

of the least observing. And this red plum had other qualities that made it well worthy of introduction. It first came into bearing in 1887, and two years later it was introduced under the name of Satsuma—the name being suggested, as was that of its companion the Burbank, by Professor H. E. Van Deman. The name seemed highly appropriate because it was the name of the province from which the plum had come.

Satsuma and its greatly improved hybrid descendants have been most welcome additions to the fruits of America.

The original Satsuma is especially popular in southern California and in the more eastern of the Gulf States as well as in the Southern Hemisphere. It is a good healthy tree with rather narrow pointed leaves of medium size. It is not so adaptable to varying climates or conditions as the Burbank, being better suited to temperate and semitropical climates. Nevertheless it fruits well in some parts of New England. It is not large enough for general shipping, but is grown mostly for home use.

The fruit is globular and usually averages nearly two inches in diameter. The skin is red, covered with a thick pale-blue bloom. The flesh is a dark purplish red, firm and of excellent qual-

ity when thoroughly ripe, though not to be compared with some of the hybrids which have been produced from it. It is esteemed for the table when fresh and for making jellies and jams.

Such peculiar interest attaches to this unique plum that I will quote an account of it given in "The Plums of New York," published in 1910:

"There is a group of several varieties of Triflora plums unique in having the flesh deep red in color and very firm and juicy. Of these red-fleshed plums, Satsuma was the first to be introduced into fruit-growing America and is one of the parents of most of the others. While the fruit is not as large nor as handsome in color as in some of its offspring, it is still one of the best varieties for quality of fruit and its trees are possibly as good as those of any of the other sorts of red-fleshed Trifloras, besides being one of the best of its class in quality for either dessert or culinary purposes, keeps and ships very well, and if the plums are of sufficient size and have been allowed to color properly, the variety makes a good showing on the markets. Too often, however, it is so unattractive as it reaches the market that it does not sell well. In the South the plums are said to be much attacked by brown

NINE VARIETIES OF CROSS-BRED PLUMS

The picture shows some of the first crosses between the Burbank and the Satsuma. The various specimens here shown illustrate the variety of characteristics that come to the surface when different races are crossed. The bloom and crimson of the Satsuma and the orange of the Burbank are clearly in evidence. There is a wide enough range of variation as to size, flesh, stone, flavor, and sundry other characteristics to afford ample opportunity for selection.

rot, but they are not more susceptible here than other plums. The trees are rather above the average for the species in size, habit, health, hardiness, and productiveness, though they bear sparingly when young.

"They bloom early in the season and are distinguished from other Triflora sorts by having many spurs and short limbs along the main branches.

"In 1887 Burbank's tree was the only one bearing in America, but since then it has been tested in all of the large plum regions, having been introduced by Burbank in 1889. In 1897 it was added to the fruit catalog list of the American Pomological Society.

"Tree medium to large, vigorous, upright-spreading, usually quite hardy, moderately productive, bearing heavier crops as the trees become older.

"Fruit mid-season or later; one and seven-eighths inches by two inches in size, variable in shape, ranging from roundish-cordate to somewhat oblate, flattened at the base; color dark dull red, with thin bloom; dots numerous, of medium size, russet, somewhat conspicuous, clustered about the apex, stem slender, three-eighths inch long, glabrous; skin of medium thickness and toughness, semiadherent; flesh dark purplish-

red, juicy, tender at the skin, becoming tough at the center, sweet, with an almondlike flavor; of good quality; stone semiclinging or clinging, seven-eighths inch by five-eighths inch in size, oval, strongly pointed, rough, tinged red; ventral suture narrow, winged, dorsal suture grooved."

Descendants of the Satsuma

The red-fleshed plums because of their unique appearance have found a place especially in home orchards. On some markets, particularly in the northern part of the United States and Canada, there is a good demand for them as shippers. Eastern markets of the United States generally prefer plums of a lighter colored flesh.

So far as known, no one else has taken up the work of the production of red-fleshed plums. Nine others, however, in addition to Satsuma, have been introduced from my farms. These include Delaware, Santa Rosa, Beauty, Apple, Duarte, Hermosillo, Rubio, Prize, Sultan, and some ten or twelve others.

The quality of some of the red plums is unexcelled by any others, and they are especially liked for making jellies, jams, etc., adding a richness of color which is not obtainable with

any other tree fruit. Often the red-fleshed plums are added to other fruits for the purpose of producing an attractive color and desirable flavor. They also serve a useful purpose in furnishing a pleasing variety of fruits.

The Satsuma and Burbank were the only two among my twelve seedlings that were directly introduced, although sundry of the others subsequently had a share in the production of hybrid races. It should be recalled also that I had somewhat earlier introduced three plums of oriental origin, namely, the Abundance, Chabot, and Berckmans, that were also the direct product of oriental stock, grown and fruited by me from seedlings purchased from other importers.

I have not dwelt at length on them here because they seem of relatively less importance at this date than they appeared at the time when they were introduced.

Together with the Burbank and Satsuma they make up a group of five plums that were grown from imported seedlings, without scientific hybridization, that ultimately came to be known wherever plums are grown.

But the Satsuma was the last plum introduced by me that was grown without hybridization from imported stock.

My next and all subsequent introductions were from new races produced by crossing and hybridization, combining the heredities of widely varying species, and selecting the best from among millions of seedlings. The story of the experiments through which these new races were developed belongs to the next chapter.

BURBANK PLUMS AND HOW THEY WERE PRODUCED

METHODS WHICH BROUGHT UNPRECEDENTED SUCCESS

"NATURE tells every secret once," says Emerson.

And this, after all, is only the poet's way of saying that there must always be some one who is first to *listen* to the secrets that nature is *telling* every hour.

At least once in my life I was privileged to listen to a secret that others had refused to hear or had heard but vaguely. Doubtless it had been whispered or half-whispered in many another ear. But in my ear nature chanted this secret perpetually, insistently, and in compelling measure.

She told and retold it to me until I had no choice but to listen.

The secret was this:

New species of animals and plants often originate through the hybridization of old species.

Stated otherwise this means that so-called "spontaneous" variation, which Darwin found so mysterious, is really due, or for the most part due, to the bringing together of diverse ancestral strains through cross-fertilization and their new responses to present environment.

It is varieties thus developed that furnish material for the operation of national selection, through which—as Darwin taught us—new species have been evolved in the past and are still being evolved.

I think I had more than half fathomed this mighty secret before I had made extensive experiments in plant hybridization. But in any event I had not gone far with my experiments in plant development before I found evidence piling up on every side to reassure me that what I had heard was no illusory voice but the voice of nature herself.

Doubtless no single tribe of plants served me better in this connection, or were more obviously the medium through which nature's great secret was revealed and corroborated, than the tribe of plums. And in the forefront of the company, in this connection, must be named the twelve little seedlings from Japan.

If I had entertained any doubt as to the correctness of these premonitions, the results

achieved when these Japanese plums were allied with other species from different parts of the globe would have settled the matter forever in my mind.

For when these immigrants from the Orient were mated with European and American stock, I saw produced "spontaneous" variations from the ancestral type of either parent in endless profusion—just such material as would be available in a wild stock for the operation of natural selection.

And ultimately, as will be told more at length in another connection, when I made still wider hybridizations, in which the apricot was one member of the alliance, there was produced a new plant so widely divergent from either of its parent forms that few botanists if any would be disposed to deny it the rank and title of a new species.

I refer of course to the plumcot.

Having been, as it were, the agent of nature in the development of this new species, I could never in future question the method through which species are commonly produced.

This method was applied in very numerous other cases with corresponding results, as will appear in due course; but for the moment the plums have the platform and we are chiefly con-

A KELSEY-BURBANK HYBRID

The plum here shown duplicates in many ways the appearance of the original Kelsey-Japan parent. It is not as palatable as it looks, but is shown as illustrating how a crossbred fruit may simulate the appearance of its most valuable parent, and yet have no commercial value whatever. (Natural size.)

cerned with their share in the interesting and important revelation.

Why Individuals Vary

Doubtless I should never have been led to hearken to nature's voice in regard to the development of species, notwithstanding its insistence, had it not been my good fortune to be passing through the most receptive period of adolescence just at the time when the new teaching of Darwin created a turmoil in every field of thought.

To me, from the outset, the teaching of the evolutionist carried absolute conviction.

Having no preconceptions to overcome, I was receptive to a point of view that to older men schooled in another line of thought seemed repellent or difficult. To me it seemed almost axiomatic that Darwin's teaching about the flexibility of species and the evolution of one form from another expressed the simple truth; for I had not been trained to observe nature from the opposite point of view, as most of my elders had been trained.

So I cannot recall the time when the word "species," as applied to any animal or plant, was for me anything but a convenient symbol to designate a more or less transitory condition in

which a particular family of organisms chanced at a particular time to find itself.

Following the teaching of Darwin, I could readily perceive that no two individuals of any species are alike; but that, on the contrary, variation is the universal rule in nature. And it was in following up the clues thus suggested that I came to believe that the explanation of this variation must be sought in heredity.

I reflected that each normal organism has an ancestry that takes in vast numbers of individuals if we go back only a few generations—eight great-grandparents, thirty-two in the generation before, and more than a thousand within ten generations.

How then could the descendant of such a galaxy of ancestors, carrying the potentialities of all their traits, be otherwise than a complex organism not only different from either of its parents, but different also from any single member of its entire ancestral clan?

It seemed also a reasonable enough assumption that, where such a multitude of more or less divergent traits are brought together and put in conflict, the exact combinations of traits would be different in the case of each successive offspring of any given pair of parents; so that no two individuals of the same fraternity would be

precisely alike, any more than any one of them would be precisely like any individual ancestor.

In a word, then, it seemed obvious to me that the individuals of a species constitute a variable and plastic race, in virtue of their diversified ancestral strains.

And if such variations are the natural result of the operation of the laws of heredity when closely similar individuals, ranked as of the same kind or species, are mated, it seemed reasonable to expect that still wider divergences and diversities must be brought about in the offspring of a union between individuals so conspicuously dissimilar as to be ranked as members of different species.

Part of this, to be sure, was matter of common knowledge; for certain examples of the hybridizing of species in the animal world has long been familiar, the case of the mule being perhaps the most striking one under everyday observation. But this particular case illustrates the union of species that have become so widely divergent that nature appears to put a ban upon their union; permitting, indeed, the birth of offspring, but condemning the offspring to infertility. The inference that this case typifies the result of the interbreeding of species is utterly misleading.

JORDAN PLUM

This variety is remarkable in having snow-white flesh instead of the yellowish or reddish flesh that characterizes most other varieties. It is also remarkable in its complete freestone condition. Dr. David Starr Jordan, President of Stanford University, was so much pleased with it that it was named for him. In quality it is superior. (About seven-eighths natural size.)

To be sure, the tendency to grow barriers between species is obvious enough, for everyone knows that most of the others among our domestic animals cannot interbreed at all. But, on the other hand, if species are really only races diverged from a common origin, as Darwin thought, then there must have been a time when those that are now widely separated were nearer together and hence capable of interbreeding.

And as there are infinite gradations as to the amount of the divergence between the extant species of to-day, might we not reasonably suppose there are many of these extant species that have not yet diverged beyond the point of hybridizing with the production of fertile offspring?

Testing the Theory

Just how far I had been carried along such lines of reasoning before undertaking to put the matter to a test, it would perhaps be difficult or quite impossible at this remote day to say with certainty.

But in any event my premonitions in the matter were sufficiently tangible to lead me, even when scarcely more than a youth in Massachusetts, to attempt hybridizing experiments. And the results of these experiments were sufficiently

encouraging to give me early assurance that I was on the right track.

So it was with a very definite purpose in view that I began sending to the remotest regions for specimens of different species or varieties of garden or orchard plants, having full confidence that when brought together these remote cousins —some at least—would be found that were still near enough to their common ancestral point of separation to be mutually fertile; and being further assured that in such cases there would appear offspring in which the conflict of tendencies would produce *wide* variations, giving precisely the materials that were sought for such further selections and hybridizings as would result in the development of new and improved species and varieties.

At first the experiments were carried on in connection with the general nursery business.

But about 1884 the work had developed to such an extent that I determined to devote the tract of eight acres purchased in Santa Rosa wholly to experimental work. Experiments had been conducted with garden vegetables, plums, apples, berries, nuts, and numberless flowers previous to this time, but generally on a small scale. Now, in casting about for the most practical lines of procedure I was impressed with the demand

all about me for better varieties of plums and prunes, especially for drying and shipping purposes.

The work as a nurseryman had taught me how urgent was this demand. I determined to undertake to meet it on a broad and comprehensive scale. To lay the foundation for the real work in plums—to get the stock together, gain experience and knowledge as to the different species and varieties, and test out their possibilities—was the work of twelve or thirteen years. Indeed, I may say that the work is still going on after the lapse of almost thirty-seven years.

Yet I began to get conspicuous results almost at the outset, as will appear presently.

The Plum as Schoolmaster

In order that the work should be carried out as conceived, it was necessary that the various plums and prunes of the world should be brought together and, as it were, put into one melting pot, in which a vast number of hereditary tendencies could be combined and recombined indefinitely. The right characters must be selected and wrong ones rejected. Out of the melange would arise new varieties better fitted to meet the old requirements, or adapted to meet altogether new requirements.

The new varieties of plums have largely modified and expanded an extensive industry, making plums of the finest quality an everyday food for the masses instead of a luxury. The lessons inculcated by the experiments in hybridization through which these new races have been developed have served as a guide to countless other experimenters in plant breeding, and have made views that seemed heretical thirty years ago seem commonplace matter of fact to-day.

They have almost revolutionized the work of plant improvement.

The materials through which this really significant modification both in the practice and the theory of plant development was brought about were drawn from five great divisions of the globe —five regions with different soils, climates, and natural conditions, and with a human population of correspondingly divergent habits and tastes.

And in return the new races of Burbank plums, prunes, peaches, cherries, apples, and plumcots are being sent back vastly modified and improved to the diverse regions from which their ancestors came, and in addition are making their way in some regions where no fruit of such qualities could be grown on a commercial scale before.